THE IMPLEMENTATION OF A COLLABORATIVE
PEER INTERACTIVE MATHEMATICS
CLASSROOM LEARNING ENVIRONMENT

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ABSTRACT

In this study, the students in my Year 8 high school mathematics class and I set out to develop a functional and effective collaborative peer interactive classroom learning environment. This research was informed by the multiple theoretical perspectives of collaborative learning in mathematics education, Vygotskian learning and teaching approaches, and the Constructivist referent for pedagogic practices. Merging these perspectives into a viable foundation for our classroom practices led to the successful development of our collaborative peer interactive classroom learning environment.

Working in groups of three or four, the students developed their social norms and utilised a collaborative approach to their learning of mathematics. Groups engaged in discussion, explanation, negotiation, peer teaching, giving help, receiving help and consensus building as part of their daily routine in our classroom. I kept qualitative and quantitative records of our progress as we worked to improve our collaborative peer interactive classroom learning environment during the first six months of the school year. I collected daily fieldnotes, audio and video recordings, observations taken by researcher colleagues, learning environment surveys and a variety of other artefacts. All of this data was analysed daily, weekly and monthly, so producing the monthly narratives upon which we based our determination of the success of this implementation.

By adopting a Vygotskian perspective we utilised our peer interactive environment to develop and enhance 'scientific' and 'everyday' concepts through individual and group dynamic, overlapping (multiple) 'zones of proximal development' as well as
our classwide 'zone of proximal development'. Our constructivist perspective aided us in focusing on our prior knowledge and experiences, which in turn enhanced the effectiveness of our collaborative classroom learning environment. We utilised the MCI and CLES learning environment measures to direct our endeavours to further improve our collaborative peer interactive classroom learning environment. The detailed analysis of the data from Months 1, 2 and 3 of this implementation, coupled with highlight analysis of the data from Months 4, 5 and 6, led me to conclude that teachers and their students can develop a functional and effective collaborative peer interactive classroom learning environment based on the multiple theoretical perspectives utilised in this study.

This research improved my practice as a teacher and provided a functional and effective collaborative peer interactive classroom learning environment for the students to work in. It informed many of the calls for further research of this type and established that the theoretical concepts, upon which the implementation was founded, were valuable and useful in the practical setting of our collaborative peer interactive classroom. The findings are also valuable for the support which they offer to the latest movements in education, particularly the student-centred, outcomes-based approaches to learning and teaching. These approaches advocate the use of collaborative learning environments, and this study provides strong guidance as to how such environments can be successfully implemented.
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CHAPTER 1

INTRODUCTION

Introduction to the Study

In education generally, and in mathematics specifically, we have seen a myriad of changes in recent times. As educators we have seen and used facets of mastery learning, computer assisted learning, a problem solving approach, an investigative approach, laboratory based learning, the Journey into Mathematics programme (Bell, Rook and Wigley, 1978), Unit Curriculum (Education Department of Western Australia [EDWA], 1987), changes to senior high school syllabi and, most recently, a Curriculum Framework (Curriculum Council [CC], 1998) which has as its focus a student-centred, outcomes-based approach to learning and teaching. This study reports on the changes experienced by a teacher (the author) and his students as they implemented a research plan aimed at improving their learning and teaching environment.

The inspiration for this research came from the many international, national and local calls for more investigations into collaborative learning and teaching processes. Changes to the senior high school (years 11 and 12) syllabi and the new Curriculum Framework both involved a shift towards greater use of collaborative learning environments (Parker, 1992; CC, 1998), reflecting the importance of collaborative work as a key competency for today's youth.

Recent international developments and reviews of mathematics teaching and learning have focused on "a need for change and a new look at what is, or should be happening in classrooms" (Australian Education Council [AEC], 1990). The National Statement on Mathematics for Australian Schools comments that: children should have the opportunity to apply their mathematics in settings which develop Australia's multicultural nature. A collaborative learning environment can provide one such setting as it allows the children's mathematical experiences, which have begun at home, to interact with their learning experiences at school, all of which builds on the strengths they bring to the classroom (AEC, 1990).

In its Curriculum and Evaluation Standards for School Mathematics document, the National Council of Teachers of Mathematics suggests that "classrooms should give
increased attention to the use of collaborative learning and the discussion of mathematics by students" (National Council of Teachers of Mathematics [NCTM], 1989). Similar ideals have been expressed in British reviews of mathematics education, where it has been suggested that "opportunities for discussion between students and teachers and between students themselves should be encouraged in classroom practice" (Cockcroft, 1982). At a joint Anglo-Soviet seminar held in 1982, the view was expressed that "a general aim of education should be to foster collaborative learning and effort" (Wilson, 1983), with specific attention being focused on L. S. Vygotsky's concept of the "zone of proximal development" (Vygotsky, 1987). Vygotsky described the 'zone of proximal development' as the "difference between the levels of unaided performance a child could achieve, and the level he could achieve with aid" (Vygotsky, 1987). I saw Vygotsky's ideas supporting the viewpoint that collaborative group work would be a powerful facilitator to the learning process and thus I was determined to encompass Vygotsky's ideas, especially regarding peer interaction, into our classroom collaborative learning environment.

Adopting this Vygotskian perspective placed value on both the individual student and the group he or she worked in which led to recognition of prior knowledge as having a significant influence in the construction of our class's taken-as-shared knowledge base. Mediation between individual and collective meanings, coupled with an awareness of prior experiences, reflects a constructivist viewpoint and this became another facet of our study's multiple theoretical perspective.

As a referent for pedagogic practices, constructivism has developed significant credentials in the mathematics education community. "Classrooms which encourage this approach to learning are needed" (AEC, 1991) and a constructivist approach merges well with the adoption of a collaborative peer interactive classroom learning environment. "A willingness and ability to work collaboratively with others and value their contribution is one of the mathematical expectations which industry has of new employees" (AEC, 1990). It seems critical that mathematics classrooms become places where "students have the opportunity to work collaboratively in small groups and engage in mathematical activities which enable them to share their thinking and strategies with other students as well as their teacher" (NCTM, 1989). This was to be a focus for our implementation.

The study was very instructional to me, the teacher, because it allowed me to test the functionality or practicality of several theoretical paradigms in a genuine practical situation. One of the assumptions that form the foundation for the NCTM's
Professional Standards for Teaching Mathematics states, "the final success for any teacher is the integration of theory and practice" (NCTM, 1991). This study was a means by which I could validate my adoption of a collaborative peer interactive classroom learning environment as being effective and, at the same time, validate those learning and teaching theories upon which I believed our collaborative peer interactive classroom learning environment to be founded. According to Bell "understanding theories about how people learn and the ability to apply these theories in teaching mathematics are important prerequisites for effective mathematics teaching" (Bell, 1978, p. 97). As a full participant in this implementation, I was expecting to change my ways as a teacher as our environment developed.

The students and I set out to create an environment in our classroom where we could all actively engage in teaching and practicing mathematics - where our classroom would be a community of teachers and practitioners. By admitting into the research frame the subjective experiences of both teacher researcher participant and student participants, we were able to provide "a depth of understanding lacking in other approaches" (Eisenhart, 1988). Such classroom-based research allowed us to analyse and be critical of our emerging classroom learning environment in order to improve that environment for everyone's benefit. It was "research with instead of research on" (McNiff, 1988). It was action research. Christie stated that "at best the teacher can only provide the environment within which the students will/may learn" (Christie, 1995, July). This implementation was a joint effort between the students and I to constantly monitor and work towards improving our environment. Action research focuses on improving the educational practices one is engaged in. In fact "the main reason for action research is the improvement of practice" (Hodgkinson, 1957, p. 137). Action research means research that affects actions and our research was intended to affect our practices within our collaborative peer interactive classroom learning environment to ensure it was functioning as effectively as possible.

To assist us in assessing the effectiveness of our environment I drew on qualitative and quantitative research procedures and mixed them in a unique way. The principal quantitative input came from the learning environment measures we adopted for this purpose. In classroom environment studies, researchers have found that students' potential is enhanced when there is a "minimal difference between the actual classroom environment and that preferred by the students" (Fraser and Fisher, 1983b). I elected to administer the My Class Inventory [MCI, short form] instrument, once every four weeks or so, to "measure and monitor the students'
perceptions of the actual classroom environment and their preferred classroom environment" (Fraser and Fisher, 1983a). A second environment instrument, the "Constructivist Learning Environment Survey" [CLES], was administered once per school term, to supplement and enrich the data from the MCI surveys (Taylor and Fraser, 1991). One of the fundamental beliefs behind this study was that "the quality of life in classrooms is of great importance, and students' reactions to and perceptions of their school experiences are significant" (Fraser, 1989, p. 1). If the students are dissatisfied with their classroom environment their learning may be inhibited. In my attempt to maximise the learning potential in our classroom, I endeavoured to develop the environment to match the students' preferred model.

The influences of the global mathematics education research community, the collaborative learning movement, Vygotskian pedagogy and the constructivist referent merged into a multiple theoretical perspective and formed the foundation of this study. Adopting a teacher-as-researcher action research methodology with a mix of qualitative and quantitative processes formed the model for the implementation of our collaborative peer interactive classroom learning environment.

The one remaining issue was the clarification of whether we were to be known as a cooperative or a collaborative classroom learning environment. The following definitions were determined from my reading of the literature.

Collaborative learning: two or more students jointly work out a single solution to a problem or task.

Cooperative learning: involves dividing a task or problem into parts and having each group member complete one of the parts.

I prefer the term 'collaborate' as it better reflects joint endeavour. 'Cooperate' implies simple sharing and does not necessarily require discussion, whereas 'collaborate' involves discussion for understanding. 'Collaborate' implies "mutuality - using each other's ideas - a two-way exchange" (Goos and Geiger, 1995, July). Thus in this study the preferred term I shall use is 'collaboration'. 'Cooperation' will still be used in reference to the work of other researchers, but it is the definition above that I have in mind whenever either of the two words is used in this study.

Rationale for the Study

Substantial research evidence now suggests that "students working together in a collaborative learning environment can master material more effectively than can students working alone" (Slavin, 1987a). This would seem to imply that all the
needed research on collaborative learning has already been done and yet "anyone who reads the research literature finds that many questions are still left unanswered. Questions about mathematics teaching and learning can be investigated by teachers as well as by 'professional' researchers" (Lambdin, Kloosterman and Johnson, 1994, p. 41). So there are still some ideas to explore and teachers can do it! I wanted to contribute, and I was interested in developing a collaborative peer interactive classroom learning environment based on my multiple theoretical perspectives. So when I read what Bennett and Cass had to say:

once a clearer understanding of group processes and outcomes has been achieved the next step will be investigations of the implementation of group work in the classroom noting in particular classroom constraints and the critical role of the teacher (Bennett and Cass, 1990, p. 73),

I thought that's it - that's my study - implementing collaborative learning in our classroom, noting all the conditions and constraints, and examining the critical role of both sets of participants, teacher and students. Finally, when I discovered that "the best way to learn about what works for real students, taught by typical teachers under actual school conditions, is for teachers to become involved in trying new approaches and in sharing their findings with others" (Lambdin et al., 1994, p. 41), I knew that this was a worthy pursuit.

One of the principal features of my research was that I could link my findings "to that of research reported in the literature" (Nelson, 1981). This thesis will be "instructive" as it describes our collaborative peer interactive classroom learning environment and "outlines how the teacher", along with the students, developed their environment (Good, Grouws, Mason, Slavings and Cramer, 1990, p. 758). To be a worthwhile endeavour, this study needed to be a long term project because "if a short-term intervention can produce significant outcomes, a longer peer-collaboration program would most likely produce real educational benefits" (Phelps and Damon, 1989, p. 644), and we certainly wanted this implementation to benefit all involved. Bartolini Bussi's study "concerning the representation of threedimensional space by means of perspective drawing" (Bartolini Bussi, 1996, p. 12, italics in original) focused on long term processes but only achieved "a limited amount of school hours, between 15 and 20 distributed over three years" (Bartolini Bussi, 1996, p. 36). Since a "successful implementation of a cooperative learning environment or community takes more than a day or so to achieve" (Sapon-Shevin and Schniedewind, 1992, p. 16), it was decided to plan the implementation for the full school year, for if you believe in something, why not do it all the time? Thesis
size restrictions limited the analysis to the first semester (six months) only. This was regarded as a sufficient time period for significant changes to emerge.

Developing collaborative learning skills is "a desirable outcome in the schooling of children today" (CC, 1998). "By creating a learning environment that encourages cooperation within the group, students learn important principles for living, as well as for learning mathematics" (Artzt and Newman, 1990, p. 452). So developing our environment would hopefully benefit the students and myself as I took the next step on my professional journey to learn and teach in a collaborative peer interactive classroom learning environment.

We must view classroom change, not as the implementation of a particular innovation, but as an episode in the career-long learning of a professional. As teachers learn to use cooperative learning, they refine both their understanding of the innovation and their values and beliefs. It takes considerable time for values and beliefs to change and then be expressed in classroom practices (Fafard, 1992, p. 115).

I believed it would take at least six months, and that my beliefs would be tested as this implementation progressed but I embarked on this study because I was dissatisfied with the way I was doing things and with the way things were done at the classroom, local and system level within education. I had to change within that system. I really believed in the value of peer interaction and of collaborative learning environments and I strongly believed in what Vygotsky described as an alternative approach to learning and teaching (Vygotsky, 1963), so I acted and, together with my students, I studied this new approach to see if it could produce an effective, functional collaborative peer interactive classroom learning environment.

Statement of the Problem

Adopting multiple theoretical perspectives allowed me to examine classroom interactions between the teacher and the students, and between the students themselves, with the aim of analysing these interactions to inform further improvement of the implemented classroom peer interactive collaborative learning environment. This approach was adopted because changes to the courses structures in senior high school required the use of an effective collaborative learning environment (Parker, 1992) and the new Curriculum Framework (CC, 1998) strongly supported the use of collaborative learning environments.
Cooperative learning has been researched for many years. However, as Graves noted, "schools with cooperative learning groups even as part of their daily instructional repertoire are still in a minority in every country" (Graves, 1992, p. 63). The fact that:

every aspect of cooperative learning theory and practice seems to be
the subject of dispute among researchers except that they all agree that
students benefit when they can help each other learn instead of having
to work against each other or apart from each other (Kohn, 1991, p. 83)

illustrates why collaborative learning is conducted only as a 'minority' practice among teachers. This one point of agreement among researchers reinforced my adoption of a Vygotskian approach to our collaborative classroom environment. Given that nearly all other aspects of collaborative practice seem to be in dispute I believed that my 'unique' approach might yield a way forward at a time when effective collaborative techniques are sorely needed.

Coming to terms with working in a collaborative learning environment required an increased awareness on my part of the importance of discourse in the collaborative process. "Discussion is now seen as an important part in the learning of mathematics, discussion in which the students play an active part" (Wilson, 1983). The latest Western Australian education reform, the Curriculum Framework, contains a set of outcomes for the mathematics curriculum labelled Working Mathematically. This strand: requires the students to describe / justify / read / write / talk mathematics; provides students with outcomes which support their learning to read, write, talk mathematics; requires the students to engage in collaborative work; requires the students to give reasons to justify the use of their mathematics; and provides students with ownership of their learning (CC, 1998). Thus we can see how talking about mathematics plays a key role in allowing students to make important connections among verbal, symbolic, pictorial, physical, graphic and mental representations of mathematical ideas. "Opportunities for conjecture, to explain and defend one's ideas both in writing and orally can help develop understandings of concepts" (NCTM, 1989). Classrooms must "actively involve groups of students in discussing, listening to, reading and writing mathematical ideas" (AEC, 1991). Our collaborative classroom involved much more than just wide ranging discourse. We worked together to improve our understanding of the mathematics we encountered, and discussion was but one vehicle in that process, albeit a very significant one. As well as extended discourse and the development of collective solutions to tasks or problems, our definition of collaboration also involved "developing explanations that are meaningful to someone else and trying to
interpret and make sense of another's ideas and solution attempts as they evolve" (Yackel, Cobb, Wood and Merkel, 1990, p. 35). Thus our emphasis focused on collaboration through discussion and explanation to enhance our collective understanding of the mathematics we were studying.

The 'problem' is that "there is little research to guide teachers in the selection of practices that are conducive to facilitating learning in a collaborative learning environment" (Tobin, 1990). There simply is no guide to successful implementations of collaborative learning environments at high school level, and that information which does exist is quite dated. Collaborative learning methods have yet to incorporate the latest trends and developments of the education research community. Thus I sought to embrace collaborative, Vygotskian and constructivist perspectives into my mathematics classroom and determine how such an environment could function effectively. With the increasing global recognition of the significance and importance of further research into classroom practices, the educational research community has begun to acknowledge that teachers have a role to play in extending such research endeavours. Among the foci required is an examination of collaborative classroom environments, teacher change in such situations and the influence of students on these learning environments. There is also merit in investigating the research practices in the former Soviet Union, particularly the works of Lev Vygotsky.

However, I must be cautious as to how I absorb and interpret research information which I intend to apply to the implementation of our collaborative peer interactive classroom learning environment. Some reported research is flawed. In an attempt to make Vygotsky's theories more accessible, many authors and translators have "taken significant liberties with Vygotsky's original works" (Simon, 1987, p. 611). That leads to serious errors and moves the foci away from Vygotsky's own psychological theories. I have worked from translations of Vygotsky's own works, but I have also interpreted his ideas through the work of others. This approach is still relatively new, even in Russia, for "it has only been in the last 10 years that Russian education has actually felt the necessity of essential reform, with the views of Vygotsky becoming one of the bases for this needed reform" (Davydov, 1995, p. 12). Thus Vygotsky's work is relevant to the modern context of education and we have seen "several doctoral dissertations which highlight Vygotsky's work" (Moll, 1990, p. 2). Although some of these dissertations were related to education, Moll found none that examined classroom teaching or applied Vygotsky's theory in instruction. My study is one such context where classroom learning and teaching is founded on Vygotskian approaches. My study was to be similar to that of Bartolini Bussi which was "an
example of research for innovation, in which action in the classroom is both a means and a result of progressive knowledge of classroom processes” (Bartolini Bussi, Boni, Ferri and Garuti, 1999, p. 71). Being founded on a Vygotskian perspective my study would "focus on maturing patterns of change and the processes by which people are changed" (Crawford, 1996).

When researching the learning and teaching environment “the achievements of psychology must be utilised” (Wilson, 1981). Unfortunately no single theory gives a total model of either learning or teaching so "more sophisticated theories of the pedagogical process in mathematics seem necessary" (Bell, 1978). A Vygotskian perspective provides "a synthesis of multiple theoretical strands" (Wertsch, 1985). Vygotsky pointed out that "to ignore the influence of instruction on child thought, as Piaget did, excluded a very important source of change which barred the researcher from posing any question of the interaction of development and instruction" (NCTM, 1980).

In Soviet psychology children are viewed "as taking an active part in learning, structuring their experience and environment rather than simply reacting to them", making learning a continuously changing process (Menchinskaya, 1969). Vygotsky argued that collaborative social settings allow children to learn by helping and being helped, and this social context of learning can be used to extend what he called the 'zone of proximal development' so that "learners can be more effective than if they were learning alone" (Ireland, 1986). When a child is interacting with people in his or her environment and collaborating with peers or adults, their learning awakens a variety of internal developmental processes which then create the 'zone of proximal development'. These processes, once internalised, become part of the child's independent developmental achievement. What the child achieves should start with his or her own understandings and what they do should arise from their own needs. An implication of this is that student learning can be enhanced ahead of development and that through such learning "the student's 'proximal zone' can be altered" (Ireland, 1986).

With such global interest in collaborative learning, Vygotskian pedagogy, constructivism and classroom-based research, this study is well situated to help fill the void described earlier by Tobin and to add to the growing wealth of pedagogic knowledge. "We suggest that more attention needs to be paid to the nature of the junior high school classroom environment" (Midgley, Feldlaufer and Eccles, 1989, p. 988). That is what I intended to do, thereby providing new perspectives on the theoretical paradigms which guided this implementation and adding new ideas to
research at the secondary school level, for to date the majority of research has been carried out at the primary and middle school levels.

It is imperative that we look at the secondary level to see whether the theories of learning and teaching would be viable in a more complex mathematical setting, with older students, and with teachers who have (usually) a more thorough mathematics background (Koehler and Grouws, 1992, p. 125).

The demand is certainly there.

That I could do this, as the teacher researcher for this implementation, was in no doubt. "We applaud teachers who themselves assess the effectiveness of a cooperative learning environment programme, and modify it to achieve the greatest amount of learning in their own classrooms" (Stallings and Stipek, 1986, p. 750).

Thus I believe I have been able to shed light on the merits of such research.

We look forward to the day when many more teachers will initiate, either independently or in collaboration with other teachers or researchers, action research in their own classrooms. Such activity should result not only in better teaching in our schools but also in an invigorating and profitable debate about what constitutes good educational research (Lambdin et al., 1994, p. 42).

One final aspect of the 'problem' must be highlighted. I was the teacher researcher for this study. "Although my role as researcher was optional, my role as teacher was not" (Wong, 1995, p. 28). As the teacher researcher I was at all times to be a teacher first and a researcher second. With the need established for this implementation to proceed, I will now clarify my purpose in doing so.

Purpose of the Study

It was an aim of my study to empower the students to believe they had the ability, the permission and sometimes an obligation to interact with their peers and their teacher as they did their work. Strengthening their learning environment was a primary goal for this study. I had to learn what the students thought of their learning environment. "When teachers view their own mathematics classroom from the children's perspectives can they respond more directly and positively to the children's needs" (Ellerton, 1989, p. 85). My aim was to see things from the students' perspectives and hence I needed to collect data from the students to ascertain their views on the many facets of the environment as implemented. By assessing the students' perceptions of their learning environment I was informing myself of my
students' knowledge and then acting upon this information to "affect change from
decisions as to the nature of the environment and to enhance its effectiveness"
(Lubinski, 1993, p. 201).

I chose my Year 8 class as the focus group for this study because it had the greatest
potential to yield information and develop 'knowledge' (answers to my research
questions). A possible assertion for my study in this case could be "if the students
like the environment and methods used in the intervention then the theory behind
such techniques has merit and should be employed on a wider scale" (Patton, 1987,
p. 55). So the focus of this study was on the students. This study aimed to:

- develop a functional and effective collaborative peer interactive classroom
  learning environment and
- examine classroom interactions between the teacher and the students and
  between the students themselves; to analyse these interactions to inform
  further improvement of the implemented collaborative peer interactive
  classroom learning environment.

The Research Questions

The research questions to be examined by this study are:

1. What specifically is happening in this collaborative peer interactive
classroom learning environment?

2. Does working in a collaborative peer interactive classroom learning
environment extend the students into their 'proximal zones'?

The first question relates directly to the student-centred aims of the implementation.
The second question relates to my need to examine Vygotsky's pedagogic
approaches and establish the degree to which I can apply them to my classroom
teaching environment. Observations relating to these questions arise throughout the
data and narratives in Chapter 4 and are summarised and reflected on in Chapter 5.

Significance of the Study

The key to the significance of this study is that it is research about improving
practice, my practice in the first instance and the practice of others in the second
instance. My research affects my actions as a practitioner. Many teachers are
"impatient with fancy theories that try to explain everything and end up saying
nothing, and are sceptical of advice based on someone else’s experience if that experience does not seem to correspond to their own” (Toumasis, 1990, p. 32). By situating this implementation in the context of a ‘normal’ class in a ‘normal’ school setting, the resulting research findings should “complement and inform the efforts of mathematics educators to reform current curricular, pedagogical and assessment practices as well as contribute to the growing base of scientific knowledge about mathematics teaching and learning” (National Council of Supervisors of Mathematics, 1988).

The National Statement on Mathematics for Australian Schools encourages innovation and experimentation so that “all learners may have a positive experience of mathematics with teachers developing learning experiences appropriate for particular children in particular schools and without limitations or restrictions being placed on the mathematics curriculum or on the range of pedagogies adopted” (AEC, 1990). An important influence on this study in this regard was the contribution made by the learning and development theory of Vygotsky which remains virtually unknown to the classroom teacher yet provides “well structured modern alternatives to traditional theories and their applications to research” (Ireland, 1986).

There is a need for more:
  - classroom-based research;
  - teacher-as-researcher forms of action research;
  - research at the high school level;
  - research into collaborative learning and teaching processes;
  - research engaging Vygotskian perspectives applied in the classroom;
  - understanding of the constructivist referent as it applies to classroom practices.

Consequently there is a need for this implementation.

Within each of these research areas there is much that is unknown. Collectively, as combined in this implementation and applied to the classroom, all aspects are new and open to discovery. As will be seen in the review of the literature presented in Chapter 2, much of what I value in this study fits well with the new Western Australian Curriculum Framework (CC, 1998). This study pre-empted and now informs many of the changes faced by myself and my colleagues working in high schools in Western Australia.
Scope of the Study

As Briggs pointed out, "much more research is needed into both specific and broad general aspects of mathematics education, and especially when based at the normal classroom level in real school situations" (Briggs, 1981). It was important that this implementation focused on the qualitative aspects of collaborative learning and that it looked more closely at the nature of our classroom interactions in order to develop a functional and effective learning environment.

For this study our groups were to have three or four members and initially be "heterogeneous both academically and in terms of their social characteristics" (Slavin, 1987a). The groups were to be teacher selected, using available academic and social measures, as they were to have a long life and a balance was required with regard to these constraints. To facilitate better class and group discussion in these mixed ability groups the students would "work on only one topic at a time" (Cockcroft, 1982). Having carefully structured the collaborative learning groups so that the students perceived that they would 'sink or swim' together, they were encouraged to "work to ensure that every group member learns and discusses the material being learned" (Johnson and Johnson, 1991).

In order to obtain a clearer picture and a better understanding of our classroom processes, this study undertook observational research to examine collaborative learning in the classroom by involving the groups in mathematical activities, problems and tasks. "If the effects of peer collaboration are to understood, it is necessary to go beyond analyses of individual performances and incorporate analyses of group functioning over time within particular activity settings" (Forman and Larreamendy-Joerns, 1995, p. 550). Some of the characteristics of this collaborative peer interactive classroom learning environment included:

- developing relevant social norms;
- negotiating individual student's explanations and solutions into a group consensus;
- peer teaching, which allowed the students to explain things, sometimes better than the teacher, by using more appropriate language;
- establishing a less threatening environment through the sharing of problems;
- empowering the group to make decisions and evaluate importance and progress;
- enabling the group to provide help, guidance and answers for individuals who needed explanations.
The observational records for this implementation involved the following data collection processes:

- daily fieldnotes and audio recordings of each classroom lesson;
- video recordings of some classroom lessons taken by a research colleague;
- observations taken by another research colleague;
- learning environment surveys - MCI taken twice a term, CLES taken once a term;
- the usual collection of student scripts such as exams, tests, quizzes, group and individual reports, pieces of homework, peer assessments (such as group worth ratings), "buddy" reports, and other student works.

The study engaged in the following data analysis processes:

- daily reports written up from each audio tape;
- weekly reports written up from each week's set of daily reports and fieldnotes according to the chosen data categories;
- monthly reports compiled after three or four weeks and based on the weekly reports. Each monthly report was developed in a narrative style using the selected data themes to focus the observations;
- methodology reports examining the effectiveness of what had been achieved each school term to highlight future needs in regards to achieving the aims of the study and answering the research questions.

The narratives presented in Chapter 4 will link the observations (reproduced in the Appendices) with supporting details from the literature outlined in Chapters 2 and 3.

Limitations of the Study

This study pertains to the classroom learning environment implemented in my Year 8 class. As a class we met once a day, Monday to Friday, for about 45 minutes. The students, who were the participants, and I, the teacher researcher, also had six other lesson blocks each day. The students attended other subject lessons which were not necessarily organised in a collaborative learning environment format. I taught other year groups none of which were organised into collaborative learning environments. The limitations that were evident prior to this implementation mainly focused on these contexts of the study - the classroom and the school.

The study had verbal consent from the previous school principal and had a similar arrangement with the new principal appointed in the year of this implementation.
The parents participated in an evening's workshop where various aspects of the programme were outlined, and they also participated in a parent's evening exploring the mathematical content their children were to study. The parents gave their consent to the study knowing that the students had quite a degree of control as to the operation of the class and the direction the study took. Ultimately the delivery of the required curriculum, as set by the school, and the adherence to the school's policies of assessment and professional conduct had priority over all aspects of the study. Being situated in the classroom places many natural constraints on aspects of the research but offers comparative significance for a wide range and large number of teachers inquiring into similar situations. The aim was to provide sufficient detail to facilitate duplication for subsequent follow-up research or comparative studies.

Limitations relating to the methodology focused on the data collection and analysis categories, discussed in Chapter 3, however such limitations were controlled by adopting the processes of allowing the categories to evolve as the study progressed.

Chapter 5 includes a review of the limitations which emerged from this implementation and associated research methodology.

Thesis Overview

This chapter has provided the background to this study; highlighted why I implemented a collaborative learning environment in my classroom; addressed some of the issues pertaining to the implementation, and established the aims of and the purpose for the study. The key research questions were presented which illustrated the scope and significance of the study. Finally some limitations were noted.

The principal literature chapters, Chapters 2 and 3, are next and have been organised in a sequence which represents my perception of the importance of each perspective's influence on my formulation of this implementation. The sequence is mathematics education research, Vygotskian pedagogy, constructivism and learning environment research followed by action research and ethnography (the methodology). Chapter 4, the data narrative follows, then Chapter 5 presents the summary findings for the study. The observational data for the study is contained in the Appendices.
CHAPTER 2

LITERATURE REVIEW

Overview

In this study, I sought to establish a collaborative peer interactive learning environment within my Year 8 high school mathematics class. My endeavour was informed by multiple theoretical frameworks arising from my years as both a full-time professional secondary mathematics teacher and part-time mathematics education researcher, roles which were often difficult to tell apart.

The multiple theoretical frameworks informing my practice and my research involve issues pertaining to mathematics education and specifically to the use of collaborative group work in the learning and teaching of mathematics. These practices are guided and influenced by my interpretations of Vygotskian developmental theory and the constructivist referent of pedagogic practices.

This chapter deals with the literature pertinent to this study and presents an overview of the relevant research. First, trends and developments in mathematics education are examined from an international perspective and include a specific focus on input from the former Soviet Union. These readings and my interpretations are further refined and personalised by reviewing the Australian situation and my local Western Australian position.

Through these differing levels the call for further use of, and research into, classrooms engaging collaborative learning environments rings loud. This call echoes across time and the literature reflects the cycles of research interest in such classroom learning environments. The need for more work in this area is voiced in the literature of the past as well as in the literature of the present, and so I next provide a detailed analysis of the collaborative learning research literature found within the mathematics education community.

Theoretical support for my emerging approach is then described with a focus on Vygotskian developmental theory which ties together the Soviet and collaborative literature and provides a referent for the development of a peer interactive classroom learning environment. These facets are further refined by incorporating them within
a constructivist pedagogic approach which allowed me to develop specific attributes within the emerging collaborative peer interactive classroom learning environment.

The chapter concludes with a synthesis of the theoretical framework adopted, and a summary of those findings from the research literature which are relevant to my study. This is followed, in Chapter 3, by a review of the literature relating to the ethnographic action research methodology guiding the design of the study and of the literature reported from research into classroom learning environments.

MATHMATICS EDUCATION

An International perspective

Concern exists within the mathematics education community, and indeed within the educational research community generally, regarding the outcomes resulting from several decades of intense research into pedagogic practices and issues. How effective has all of this time, effort and expense been in changing and improving the education of our students? While the literature can point to a myriad of visible and measurable improvements, many educators remain unsatisfied with the published results and point to the need for this research effort to continue.

In the 1980s, the National Council for Teachers of Mathematics in the United States of America called on mathematics educators to focus on problem solving as a way forward in the quest to enhance the mathematical achievement of students. Sadly, survey results show that this focus did not yield the results envisaged (Dossey, Mullis, Lindquist and Chambers, 1988). This led mathematics educators to look more closely at what was happening in schools, and since "research on peer collaboration has been sparse" (Forman and Cazden, 1985, p. 329), calls rang out for "the greater use of small group arrangements" (Davis, Maher and Noddings, 1990, p. 1-2). "Research dating back to the late 1800s suggests that if you want more students to learn more material and be motivated to learn then you should have your students learn cooperatively" (Johnson and Johnson, 1991, p. 46). Research attention turned to small group arrangements because "small groups provide a forum in which students ask questions, discuss ideas, make mistakes, learn to listen to others' ideas, offer constructive criticism, and summarise their discoveries" (NCTM, 1989, p. 79). Utilising group work to provide "a supportive environment for learning:

- includes a cooperative and non-threatening atmosphere
- encourages risk-taking and regards errors as a necessary, acceptable and
often helpful part of learning

- includes classroom processes that give students some flexibility in choosing ways of working and encourage them to take responsibility for their own learning (CC, 1997, p. 202).

Kohn argues that collaborative learning can - and ought to - become the "default" classroom arrangement (Kohn, 1992, p. 40). While many authors comment on the fact that collaborative learning is not effective if used 100% of the time, Kohn's comments support my contention that it can, and should be, the first choice for work practice in the classroom, as was the case in this study.

My choice to transform my mathematics teaching and my students' learning was informed by my previous practical experience, and was based on research from the education community. "Research-in-action for the teacher brings together the theories with the practice of teaching" (Lerman, 1990, p. 25). Adequately informed practice, informed by theory, can develop into more effective platforms for student learning. My research "emphasises the role of students in shaping classroom events" (Cooney and Hirsch, 1990). It also emphasises that:

- teachers need to listen to students and utilise what they learn from listening; students learn mathematics best when they construct their own mathematical understanding; mathematical discussion should be a daily part of classroom activity; and students need shared learning experiences (Lacampagne, 1993).

Thus my teaching was transformed by listening, adopting a constructivist approach, encouraging discourse and developing a collaborative small group environment. The challenge remained however to bridge the gap between what the research says, and how to implement this into my classroom practice. As the knowledge base of the advantages to be found in collaborative group work built up, researchers began to seek a solution to the task of enhancing the way research informs practice. "How can we put our knowledge of the advantages of cooperative learning into practice? One way is to get classroom teachers involved in doing research in this area" (Johnson and Johnson, 1991, p. 46).

By the commencement of the 1990s, researchers acknowledged that the involvement of teachers in research was a way forward "perhaps because tightly controlled, experimental studies have not yet yielded revolutionary findings nor brought about a dramatic change in practice", (NCTM, 1980, p. 266-267), and in mathematics education collaborative learning was seen as "likely to be a fruitful area of research for some time to come" (Davidson and Kroll, 1991, p. 364). These calls for a new
direction and a re-focusing of research did not stop at involving teachers or re-
discovering the worth of collaborative learning. Greater change was needed in the
way research was carried out. Studies of longer duration using both qualitative and
quantitative measures were envisaged. "Such evaluations would enable educators to
appreciate the potential for the multifaceted forms of learning and change possible
with cooperative learning" (Sapon-Shevin and Schniedewind, 1992, p. 18). This was
the approach which was influential in the formulation of my study utilising some
quantitative measures amidst its qualitative observations. While our implementation
would last for the entire school year, limitations on document size restricted this
thesis report to the first six months of the study.

Good, Grouws and Mason, (1990, p. 15), see a need for such research "to examine
the form, quality, and effects of small-group teaching in actual classrooms in order to
obtain a clearer picture and a better understanding of current practice". Such
research "should not only contribute to the growing base of scientific knowledge
about mathematics teaching and learning but also complement and inform the efforts
of mathematics educators to reform current curricular, pedagogical, and assessment
practices" (Research Advisory Committee of the NCTM, 1988, p. 343). That means
we need to know which sections of the curriculum are or are not enhanced through
the use of collaborative learning environments. We also need to know which
teaching and learning methods are effective in such situations, and which assessment
practices remain functional or need to be modified to operate in this environment
(such as group-worked tests).

Some researchers believe that "few studies have been conducted in regular classes,
by regular teachers, in ongoing programs", (Dees, 1991, p. 411), but there have been
many such studies. "There is a considerable amount of small-scale research being
carried out by teachers in schools which is clearly not receiving recognition in the
mathematics education research community" (Lerman, 1990, p. 25). The problem
lies in researcher-practitioner communication. Research by teachers is often
regarded as 'dirty' research because it is subject to the 'realities' of school life,
whereas on the other hand, many attempts at classroom-based research are carried
out by persons in circumstances divorced from the school environment. "As the
teacher I felt no pressure to teach from a preset curriculum nor to 'cover' particular
mathematical content, a condition that is probably the exception rather than the rule
for mathematics teachers" (Simon, 1995, p. 136). This statement indicates that many
researchers have enjoyed considerable allowances in the time provided for their
research program to be completed. In my study I adopted the approach of trying to
follow the underlying paradigms without any such concessions. No time
adjustments beyond those normally associated with getting ahead or behind in a topic, due to factors mainly external to the class (like whole-school events); no adjustment to the curriculum for content or quantity and so on. I ran the implementation for a full school year rather than as a one-topic variation in teaching style, consequently the theoretical frameworks were translated into a practical study which underwent a rigorous trial in the classroom situation.

Such practices are mirrored in the early mathematics education practices of the Soviet research community which influenced and informed my earlier research (Ireland, 1984; 1986). The influences of Soviet studies into mathematics education procedures should be "given consideration when developing modern research methods" (Kilpatrick and Wirszup, 1969-1972, 1975; Kilpatrick, Wirszup, Begle and Wilson, 1975a, 1975b, 1975c, 1975d, 1975e, 1975f, 1975g; NCTM, 1980, p. 15-16). In comparing Soviet and American approaches to educational research, Kilpatrick and Wirszup, (1969-1972), note that the Russian approach "often uses quantitative methods of research in instructional psychology in accordance with the prevailing European tradition". Another comparison noted that "instructional treatments used in Soviet research are often not short clinical studies but rather the instruction occurs in school settings over extended periods of time, sometimes an entire academic year" (NCTM, 1980, p. 178-180). While these practices may have been dominant in Soviet Russia during the 1970s and the early 1980s, they were not enduring beyond that time. Subsequent work seemed to become excessively Westernised and criticisms began to surface. A principal shortcoming was that "research does not contribute enough to the needs of real-life educational practice" (Pruchna, 1990, p. 668). Research, if carried out at all, had "been performed primarily in laboratory settings and their results did not fit in adequately with real-life conditions of education (Pruchna, 1990, p. 668).

Such inadequacies reflect more the changes occurring in Soviet society at the time than changes to pedagogic research practices, for by the early 1990s much of what made Soviet research unique was again evident in the practices of researchers in the new Russia. One trend evident in recent Russian research is towards an increased study of collaborative learning processes. For example, it is Davydov's view that studying "the collective activity of people, especially children", or collaborative learning, "will give rise to research results of practical significance to the quest for improvement in education" (1995, p. 16). Such problems "have in the last few years become a subject for deeper study" (Davydov, 1995, p. 16). A major influence on the Soviet approach was directed by the works of Lev Vygotsky and this influence has now spread to the West. "Teachers need to take a more active role than
suggested by a Piagetian approach. They need to investigate ways of structuring independent group learning situations incorporating ideas from a Vygotskian perspective" (Higgins, 1995, April, p. 20) and this is what was attempted in my study.

"Vygotsky's theoretical perspectives merit the attention of the mathematics education community" (Schmittau and Taylor, 1993, p. 1). My study gives attention to Vygotsky's works and places them firmly in the world of a 'real' mathematics classroom. "Many of Vygotsky's ideas seem directly relevant to issues in education" (Moll, 1990) and researchers who "have been actively searching for new theoretical frameworks" (Wertsch and Tulviste, 1992, p. 548) see Vygotsky's ideas as addressing many of the issues that have motivated their quest. Vygotsky focused on "the intertwining between instruction and development during the school-age years" (Pontecorvo, 1990, p. 12) and yet "research up to now has been more focused on preschool child development" (Pontecorvo, 1990, p. 12). Thus my study extended the areas to which Vygotskian concepts have been applied, and did so within a school context - the 'real' source according to Vygotsky.

The literature indicates international support for changes to classroom pedagogic practices through the use of collaborative learning environments and for changes to research practices, including the adoption of Soviet pedagogic research procedures and the use of a Vygotskian theoretical approach. Much of this support focuses on the need for greater awareness of the social and cultural domains of the classroom to facilitate effective development of a collaborative learning environment.

"The mathematics classroom envisioned by the reform movement is one in which the teacher's role is to facilitate students' learning. This is to be accomplished in the context of small group and whole-class settings in which teachers assist students to build their own understandings of mathematics" (Brown, Stein and Forman, 1996, p. 64).

This would include the need for a better understanding of what it means to work collaboratively or in groups. Fey (1981) found that "the pattern of activity in mathematics classrooms has changed little" over time and Good, Grouws and Mason, (1990), found that "only 5% of teachers used two or more groups in which students were encouraged to work cooperatively". Some researchers "utilise a great deal of group work" in what they do (Bell, 1993) however, "the limited amount of research undertaken in Britain indicates that children work in groups, but not as groups" (Bennett and Cass, 1990, p. 57). That is to say the classroom is physically arranged into groups of students but the students are not working collaboratively in these
situations. "Many mixed ability classes observed, however, demonstrated that the practice of having small groups of pupils working together for particular aspects of a subject was rarer than the whole class working together or the pupils working as individuals" (Pickles, 1986, p. 48-49).

Despite these shortcomings, group work remains a favoured pedagogic approach among researchers around the world. "Both the New Zealand Curriculum Framework (1993) and Mathematics in the New Zealand Curriculum (1992) highlight the importance of group work in the promotion of mathematical processes" (Higgins, 1995, April, p. 2). "Fostering processes which enhance learning involves teaching students to work with peers" (CC, 1997, p. 202) so that "the focus of judgements may be by groups of students" (CC, 1997, p. 174) who "recognise when collaboration will enhance their work. They work well with others and contribute in various ways, sometimes leading and sometimes following, accepting, sharing, integrating or adapting ideas from others and building on various positions flexibly and responsively" (CC, 1997, p. 25). Thus support for group work comes explicitly from Australia, New Zealand, the United Kingdom and the USA in the form of their various national, state or county statements, and it also comes extensively from the work of researchers in many fields, not the least of which includes mathematics education, constructivist philosophy and educational psychology. Research has perceived many tangible benefits from the use of groups in the classroom. "Of 67 studies of the achievement effects of cooperative learning, 41 (61%) found significantly greater achievement in cooperative than in control classes. 25 (37%) found no differences, and in only one study did the control group outperform the experimental group" (Slavin, 1991, p. 76). These figures give credibility and acceptability to collaborative learning practices.

Some teachers are still uncertain about adopting collaborative learning methods for their classrooms. Common concerns include delays in completing a set syllabus, concerns that a collaborative learning environment only suits particular student and/or teacher personalities and that such environments make excessive demands on the teacher's time. From my experience, these points have a degree of truth about them. However, teachers and students are quite versatile and I believe that, regardless of the preferred delivery technique, any teacher could successfully incorporate some aspects of collaborative work into their class if they wished to do so. As for the students, the majority have experienced some form of collaborative work through their primary years (Years 1 to 7), so they are all potentially receptive to that style of learning. "In order to address these sorts of concerns, it seems important to test cooperative methods in ordinary, already existing courses, using
simple procedures that could be easily duplicated by other teachers" (Dees, 1991, p. 411). This precisely describes my study. As the pedagogic approach in the primary grades often involves a group-based collaborative approach, I chose a first year high school class for my sample. "Students who are introduced to cooperative learning strategies in elementary and middle school are likely to be more amenable to such methods when they reach high school" (Sutton, 1992, p. 65) and research provides even greater motivation for the implementation of a collaborative learning environment in the early years of high school. A study by Parker (1992), who examined the implementation of a new senior high school mathematics syllabi in Western Australia, found that senior (Year 11-12) students needed to be able to work collaboratively in the new syllabus subjects, and so proposed using collaborative learning in the lower grades (Years 8-9-10) to enhance student learning by the senior years.

A collaborative learning environment offers teachers and students the opportunity to develop important life skills. Mathematics classes have long been criticised for failing to reflect changing social and work practices. "Very little opportunity was given for the pupils to express themselves orally in mathematics lessons" (Pickles, 1986, p. 49). "Not many opportunities are provided for extended discussion, for collaborative work in groups" (Pickles, 1986, p. 48-49). Paragraph 243 of the Cockcroft report includes a comment that "mathematics teaching at all levels should include opportunities for discussion between teacher and pupils and between pupils themselves" (Cockcroft, 1982, p. 71-72). A collaborative learning environment can provide these opportunities. Research findings dispel many of the myths that surround the advantages and disadvantages which some teachers perceive of collaborative learning - for example, "high achievers gain as much from cooperative learning as do low and average achievers" (Slavin, 1991, p. 77). Many teachers believe collaborative learning disadvantages high achievers. A further concern for teachers involves the length of time collaborative learning groups should remain together before new groups should be formed. "It would be interesting to examine this pragmatic question in the classroom. You might try different lengths of time or search for crucial signals that groups should be changed" (Johnson and Johnson, 1991, p. 48). My study addressed this matter. Group changes were planned but the formulation of the groups and the students' reactions to their placement in these groups were the principal influences relating to the length of time that the groups remained together. "Grouping on the basis of content and stage of learning appears to be shifting to grouping for social interaction in New Zealand schools" (Higgins, 1995, April, p. 4). While this technique recognises the importance of social interaction in students' learning, my study took a less liberal position for the initial
stages of the implementation. It is only by trying these various approaches in our classrooms that we will be able to determine the most effective strategies and environments in which our students can learn.

Gallimore and Tharpe see "cause for optimism in schools increased use of small groups" and the "maintenance of positive classroom atmosphere" (1990, p. 198). Indeed many investigators into the outcomes of collaborative learning emphasise the benefit of the development of positive attitudes. The research community sees the promotion of such outcomes as a part of the teacher's duty. "Mathematics teachers need to accept as a major task the responsibility for establishing a mathematical environment in their classrooms" (Davis et al., 1990, p. 2). Bishop and Nickson suggest that "pupil-centred teachers produce better attitudes to learning and higher attainment on the part of pupils" (1983, p. 16). As part of being a pupil-centred teacher one must take into account the students' attitudes to their learning environment.

Paragraph 243 of the Cockcroft report reminds teachers that "positive attitudes assist the learning of mathematics while negative attitudes not only inhibit learning but very often persist into adult life and affect choice of job" (Cockcroft, 1982, p. 101). Student attitudes come from those of their teachers, parents and peers. Attitudes to mathematics correlates to attitude to school in general and students also develop peer-group attitudes. "These things do not seem to be related to type or size of school or to subject content" (Bell, Costello and Küchemann, 1983, p. 254).

As a result of the kind of mathematical experience students will have had at primary level and, more particularly, their achievement or lack of it with respect to the subject, attitudes to it are likely to be entrenched by the time they enter secondary school (Bishop and Nickson, 1983, p. 20).

The students' attitudes, as measured by classroom learning environment instruments, also influenced this study and the environment we created.

Thus the international perspective described in the preceding pages recognises the significance and importance of further research into classroom practices and acknowledges that teachers may have a role to play in this process. Among the foci required is an examination of collaborative classroom environments, teacher change in such situations and the influence of students' attitudes on these learning conditions. There is also merit to investigating the research practices of the former Soviet Union, in particular the works of Lev Vygotsky. With such 'global' interest in classroom-based research, my study is well located to add to the growing wealth of
pedagogic knowledge. In the next section I focus specifically on trends in mathematics education in Australia.

The Australian scene

As is the case in the international arena, Australian mathematics education researchers, and those in other fields, recognise the important influence that attitude has on a student's learning potential. "Teaching will be influenced by abilities, attitudes and experiences of students" (AEC, 1991, p. 16). The Australian National Statement on Mathematics describes an important aim of mathematics education as being "to develop in students positive attitudes towards mathematics and their own involvement in it, and an appreciation of the nature of mathematical activity" (AEC, 1990, p. 31). The Curriculum Council of Western Australia holds similar views describing mathematical outcomes which aim to develop the student's appreciation of "the role mathematics has had, and continues to have, in their own and other communities" (CC, 1998, p. 180). Willis views one goal of schooling as the maximising of a student's "capacity to continue to learn mathematics, possibly independently" and she emphasises that students "need to leave school with a positive attitude towards their continued involvement in mathematics". Willis also acknowledges that "this is a very tall order" (Willis, 1991, p. 6). The wider community also holds the expectation that "school must develop positive attitudes" (AEC, 1991, p. 22) and so we have a growing interest in this field of research. "Areas such as attitudes and appreciation require renewed research attention" (Watson and Atweh, 1992, p. 18).

The Australian National Statement on Mathematics describes teaching methods which are "likely to encourage productive learning strategies and positive attitudes towards involvement in mathematics". The Statement encourages innovation and experimentation so that "all learners have a positive experience of mathematics" (AEC, 1990, p. 1). There is no single 'best' approach to teaching mathematics and the Statement should not be interpreted as "placing limits on the range of pedagogies adopted" (AEC, 1990, p. 1). Indeed, "a teacher may vary the teaching style according to the particular aspect of mathematics being studied at the time and the previous experiences of the students" (AEC, 1991, p. 10). Many view this formulation or approach as being strongly influenced by the constructivist approach to learning and teaching. Students "should be provided with a rich variety of teaching approaches, strategies and situations to develop their potential and to learn in ways which are most appropriate for them as individuals" (CC, 1997, p. 36).
Research into the pedagogic practices of teachers in Australia has found that "more than any other subject, mathematics tends to be taught in a traditional way, with students working individually and competitively - a learning style which doesn't appeal to girls" (Department of Education, Employment and Training [DEET], 1992, p. 2). As my study was implemented in an all girls school, this finding had significant influence on my perceptions of an effective learning environment for my class. Informed by these findings and by my interpretations of Vygotsky's socio-cultural approach to education, I chose to implement a collaborative peer interactive classroom learning environment which found support in its empathy with the natural way students learn. Higgins (1992, p. 2) found that her "observations supported Corsaro's (1985) claim that in most instances children chose to work with others rather than alone". The Australian National Statement on Mathematics extends this naturalistic view, for it sees "the process of developing and building up mathematical knowledge as coming about through the interaction of communities of people working mathematically and sharing ideas. School mathematics should encourage and strengthen these ways of working" (AEC, 1990, p. 13-14). The Curriculum Council of Western Australia links the learning environment and the curriculum when promoting mathematical challenges for students. "The curriculum should seek to challenge and extend all students in mathematics but within a supportive environment for learning" (CC, 1997, p. 192).

There is another issue to address which goes beyond the social and cultural aspects of community influence on student learning and also beyond the teaching practices students encounter or their attitudes to schooling. This is the question of why mathematics is important. "Mathematics can enhance our understanding of the world and the quality of our participation in society. Since it is valuable to us individually and collectively, it should be an integral part of the general education of every young person" (CC, 1997, p. 170). The Australian publication A National Statement on Mathematics views mathematics as being important for several reasons:

- an international 'body of knowledge' of mathematics has resulted from the convergence of mathematical activities of many cultures, both past and present
- our ways of thinking influence, and are influenced by, mathematics
- mathematical thinking is part of the cultures of origin of all Australians
• mathematical ideas are an integral part of a general education and are valuable individually and collectively as they are used in everyday life by the majority of people (AEC, 1990, p. 5-7).

Mathematics is an important part of every student's education. "Mathematics is integral in the education of young people" (CC, 1998, p. 213). The outcomes of mathematics education contribute, directly or indirectly, to all educational outcomes. "In addition, through numeracy, it provides learning skills which contribute to the achievement of the outcomes for most of the learning areas of the curriculum" (CC, 1998, p. 213). There are many influences affecting the student's learning of mathematics: teachers' pedagogic techniques, the student's social and cultural background, their attitude to the subject and the environment within which they learn. This is a very complex situation but "we all need to understand our own classrooms" (Ellerton, 1993, October). If we pursue this understanding through a formal research project, as I have done with this study, then "you need to be a part of the school and its community" (Ellerton, 1993, October), to "deliberately set up teaching experiments in classrooms" (Bishop, 1995, July). "Teachers as professionals who work in a complex environment should assume responsibility, ownership and control over their own practices" (Yoong, 1992, p. 56). Schon (1987) believes that "professionals should continually open themselves to new competencies through the process of discovering new meanings about their practices and about themselves".

Reflecting trends on the international scene, the research situation in Australia sees an agenda of student attitudes, pedagogic innovation and experimentation, valuing mathematics as a subject to learn, and classroom practices including collaborative environments. Frequent calls for more research are evident as is the recognition of the value of teachers carrying out some of this research. We see here a 'national' interest in classroom-based research further enhancing the potential of my study. Next we examine the mathematics education perspectives evident in my home state.

The Western Australian situation

Many changes have occurred in the teaching and learning of mathematics in Western Australia over the past fifteen years. In my time as a high school mathematics teacher the most significant of these changes have been:
• Early 1980s - a change to a "let the learner learn before the teacher teaches" style of instruction incorporating material from the Journey Into Mathematics program authored by the Shell Centre, Nottingham, U.K. (Bell, 1983). The principal
focus here was to expose teachers to a more student-centred, activity-based approach to mathematics instruction. This change extended from Year 8, the first year of high school, through to Year 10, the final year of compulsory schooling, and it has remained in place since.

- **Late 1980s - a change to a unit style curriculum for Years 8, 9 and 10.** This change attempted to bring the lower high school mathematics syllabus into line with the instructional techniques now developing. The unit style curriculum ceased being used recently, but the syllabus remains as it was originally.

- **Early 1990s - changes to mathematics in the senior high school (Years 11 and 12) incorporating the newly-developed instructional techniques and a very problem-centred and investigation-based set of syllabi.** This change remains.

- **Late 1990s - a change to an outcomes-based approach to learning and teaching with the development of the Curriculum Framework (CC, 1998).**

  The Curriculum Framework sets out what all students should know, understand, value and be able to do as a result of the programmes they undertake in schools in Western Australia, from kindergarten through to Year 12. Its fundamental purpose is to provide a structure around which schools can build educational programmes that ensure students achieve agreed outcomes. This focus on outcomes represents a major shift in school curriculum from one on educational inputs and time allocation toward one that emphasises the desired results of schooling (CC, 1998, p. 6).

  This study was formulated and implemented prior to the launch of this outcomes-based Curriculum Framework. Thus while this latest change has no direct input into my implementation there are many strong links between what this study achieves and the goals of the Curriculum Framework.

Thus I found myself developing new pedagogic skills as a result of these (and other) changes. Not all change translates into successful practice, although these changes contributed to my search for a more effective classroom learning environment. Also, influencing my perceptions of better practice were research reports which reflected on or reviewed some of the changes being applied to mathematics education in Western Australia. Support for my views that a class should be built around a basis of collaboration came from the Western Australian Education Department. "Although there are times when students should work as individuals, and times when the class should function as a whole, these situations should flow from and to a classroom structure operating with the small group as its basis" (EDWA, 1984, p. ix). One further influence came from a report which reflected and impacted directly on my personal experiences. In teaching courses within the new senior high school
mathematics syllabi (Years 11 and 12) I had found that using collaborative group work was essential to the effective implementation of the course work. However, by Years 11 and 12, students were experienced individualists who thrived in a competitive system which provided very little opportunity for collaboration. One analysis of the implementation of the new courses found that "a number of problems have emerged in relation to the use of group work" (Parker, 1992, p. 7). One recommendation for future action from this research was to "incorporate more group work in lower secondary mathematics" (Parker, 1992, p. 9). My study attempted to do just that.

The local perspective reported here shows how mathematics education has experienced nearly constant change over the past 15 years. Many of these changes have incorporated aspects of collaborative classroom practice, and the most recent research indicates that such learning environments are critical to the students' continued success with mathematics syllabi in the senior years of high school. I believe my study to be well situated within the trends evident in the local mathematics education community.

Summary - Mathematics Education

In reviewing international, national and local perspectives on mathematics education one facet is evident. "Over the 20th century, there has been little fundamental change in the way in which we organise teaching and learning in schools" (Nadebaum, 1993, p. 10). The reality which educators must address as they prepare their students for the future is described by Nadebaum as "one of multiple jobs, both paid and unpaid, and varying career paths, many of them not yet existing, with the new learnings, skill acquisition, retraining and periods of unemployment that go with this" (1993, p. 11). Therefore, among other things, we should teach our students to learn and collaborate. "Education is about learning to learn" (Nadebaum, 1993, p. 11).

Further research is needed and teachers have a role to play in providing much of the data investigating classroom practices today. Collaboration, student attitudes, innovative pedagogic practices and more all contribute to the resulting learning environment. International, national and local trends reflect these and other perspectives. Of particular interest is the growing awareness of Soviet pedagogic practices, especially those based on the work of Lev Vygotsky. This study brought these multiple perspectives to bear in my classroom as I examined the resulting collaborative peer interactive learning environment. In the section which follows I review the literature on collaborative classroom practice.
COLLABORATIVE GROUP WORK

More research is needed

In describing activities within mathematics classrooms, the Western Australian Curriculum Framework advocates that "learning experiences should encourage students to learn both independently and from and with others", that is providing "opportunity for both individual and collaborative learning" (CC, 1998, p. 36). The Australian National Statement on Mathematics advocates that "experiences should be provided to encourage in students a willingness and ability to work cooperatively with others and to value the contribution of others" (AEC, 1990, p. 32). In her presidential address to the American Educational Research Association, Ann Brown stated that "collaborative learning is not just nice, but necessary for survival" (Brown, 1994, p. 10) and yet Lambdin found that "research on peer collaboration has thus far been quite sparse" (Lambdin, 1993, p. 50). Such observations often arise as the result of a selective focus on the research area. In this study, which also examines a selection of material that has been written on collaborative learning, the criteria for inclusion incorporated relevance to mathematics education, links to Vygotskian approaches or links with a constructivist perspective.

That much research on collaborative learning has occurred is acknowledged, however "research findings stress the need for further research to provide teachers with adequate principles and guide-lines to enable them to make decisions relating to the appropriate use of cooperative small-group instruction in mathematics" (Mulryan, 1992, p. 262). Despite all that has been achieved, more can still be done because collaborative learning is "a teaching strategy that holds promise for improving the mathematical skills and attitudes of students and plays an important role in the student's ability to learn mathematics and increase students' confidence in their own ability to do mathematics" (Artzt and Newman, 1990, p. 448). Being a teaching strategy it is important for teachers to "keep experimenting until they find what works best in their classrooms" (Edwards and Stout, 1990, p. 40). Such experimentation must take account of the wealth of successful investigations into collaborative learning, and secure this with a functional and stable theoretical base. For me a Vygotskian approach provides the required theoretical base. "Vygotsky's idea that children's mathematical knowledge develops first in a social setting, and only later becomes internalised, provides one theoretical explanation for the effectiveness of cooperative groups" (Seldon and Seldon, 1994, p. 6).
Collaboration concerns

For me, one of the deepening mysteries surrounding the literature on collaborative learning relates to what Johnson and Johnson, (1990, p. 30), describe as:

- "positive interdependence" - in a mathematics lesson the students would have to agree on the solution and strategies for solving the problems set as the instructional task.
- "individual accountability" - it is important that group members know that they cannot be carried by the others. Each member should have the correct answer and be able to explain correctly how to solve one of the problems.

For the classroom teacher, operating in a real school context, 'positive interdependence' and 'individual accountability' are difficult to reconcile.

Researchers demand interdependence and at the same time they demand individual accountability which equates to 'the group will not survive without you nor you without them, but you must survive on your own' (that is without the group). To some extent I was guilty of promoting this paradox in my own study as I enforced group work ethics and yet subjected the students to individual tests for all of their major test assessments. Teachers have to reconcile such ideas when they adopt a collaborative approach and make it their own. "Every teacher must internalise cooperative learning, and adapt it to his or her own teaching style" (Edwards and Stout, 1990, p. 39). I implemented a collaborative peer interactive learning environment in my classroom in order to examine the benefits of such an approach in a normal school setting.

An examination of the way in which different teachers present cooperative small-group work to students and prepare them for it and the expectations that they communicate to students in relation to group work procedures, task engagement, help giving and help seeking is likely to yield important information (Mulryan, 1992, p. 272).

Valuing the individual

Why then, if so much research has already been undertaken, are there still so many unresolved concerns within collaborative learning research? Society is a constantly changing structure and so our interpretations of what it means to 'collaborate' are constantly evolving. In the modern context we see "people who are cooperating and working together to learn something - encouraging and depending on each other but not necessarily seeing eye-to-eye" (Kohn, 1992, p. 41). As pedagogic practices focus on the learner as a constructor of knowledge, mathematics educators no longer pursue a policy of uniform conformity among students. "Individuals are viewed as
participating in social practices" (Cobb and Bowers, 1999, p. 5; Forman, 1996). Thus we see the emergence of the individual as a significant element of the collective as he or she jointly functions within society.

"Classroom interactions about mathematics should be characterised by a genuine commitment to communicate in which the teacher assumes that students' mathematical actions are reasonable from their perspectives even if that sense is not immediately apparent to the teacher" (Cobb, Wood, Yackel and Periwitz, 1992, p. 486). This was an area of special attention in my study in that, as the teacher, I concentrated on ensuring that students' ideas and opinions were valued, even to the point of telling them so. "The teacher accepts all answers and solutions in a completely non-evaluative way" (Cobb, Wood and Yackel, 1991a, p. 160). Such was the frequency of this type of teacher behaviour in my study that eventually the students asked why I so readily sought and accepted students' views and perspectives on various matters, especially when they were often obviously incorrect. I explained that it was because every answer or solution had a right to be heard even (or especially) if wrong. What if another or several other students shared this solution or answer? "The teacher accepts incorrect answers as viable alternatives which indicates to the students that the teacher also values their ideas. That is the teacher's obligation of listening to the students' ideas and respecting their mathematical thinking" (Wood, Cobb and Yackel, 1991, p. 600). Valuing right or wrong answers also facilitates the students working mathematically, for it encourages the students to "reflect upon and discuss successful and unsuccessful mathematical strategies" (CC, 1997, p. 192).

The fact was that not everyone, particularly the student with the answer, perceived the information as incorrect and by accepting it, I opened up their interpretation to discussion rather than dismissing it without any such discourse or subsequent explanation. By bringing it out into the open and determining its correctness, all those people with a belief in the idea can argue on its behalf and see for themselves how valid it is. A teacher can represent him or herself as non-evaluative by accepting all and sundry responses and opinions from the students. Such behaviour encourages the students to verbalise, put forward and share their ideas.

"Collaboration involves much more than combining solution procedures to develop a joint solution. It involves developing explanations that are meaningful to someone else and trying to interpret and make sense of another's ideas and solution attempts as they evolve" (Yackel et al., 1990, p. 35).
So it is not just 'the answers' we are after, but a deeper sense of meaning-making through a collaborative approach to our learning which values individuality for the variety it brings to the group, and facilitates the strengthening of the individual through his or her participation in the collaborative process. Collaborative learning attempts to enhance the individual through the social processes of working with others so that the group makes the individual 'more whole'.

**What the research literature says**

Within the scope of my study, many previous efforts to research collaborative learning environments yielded influential and informative results. The mathematics education research community has been active in this area as the following synthesis of findings reveals.

"There is now substantial evidence that students working together in small cooperative groups can master material presented by the teacher better than can students working on their own", (Slavin, 1987b), and that "achievement scores are consistently higher for cooperative learning groups" (Gordon, 1986, September). This evidence continues to grow from the significant collection of earlier work. In a meta-analysis of more than 122 studies of various types of collaborative learning, Johnson, Maruyama, Johnson, Nelson, and Skon (1981) compared the relative effects of collaborative, competitive, and individualistic goal structures on achievement. As a result of their study they found that collaboration is "considerably more effective than interpersonal competition or individualistic efforts in promoting achievement and productivity". As Davidson and Kroll (1991, p. 362) point out, "less than half of the studies comparing small-group and traditional methods of mathematics instruction have shown a significant difference in student achievement; but when significant differences have been found, they have almost always favoured the small-group procedure". This trend has continued into the 1990s with findings from studies continuing to reinforce earlier results that students achieve more when working in collaborative learning environments (Stokes, 1991, August; Williams, 1989, June; Leali, 1993, May; Thompson, 1993, February) and that they are "overwhelmingly positive to such experiences" (Berg, 1993, March).

Another benefit of collaborative learning is that it "helps to minimise teacher dependency because children assume more responsibility for their learning by being accountable to themselves and others" (Behounek, Rosenbaum, Brown and Burcalow, 1988, p. 12). Developing "increasing autonomy" in students along with reflective skills, thinking skills, collaborative skills and work management skills all
relates to gaining greater "responsibility for their own learning" (CC, 1998, p. 36). This implies a degree of commitment by each student to the task of learning, something which the students are quite capable of doing as the findings of several studies have shown. "Students working in cooperative small groups in mathematics tended to be more active learners and were more highly motivated than students working in whole-class settings" (Mulryan, 1994, p. 281; Mulryan, 1992, p. 270; Artzt and Newman, 1990, p. 451; Good, Reys, Grouws and Mulryan, 1990). These findings do not imply that being passive is an indication of failing to achieve. In fact, a collaborative learning environment provides a situation in which the students can still enhance their learning through a form of passivity which involves actively listening to others. Peterson and Swing (1985) found a significant positive relationship between listening to others' discussion and achievement. This finding suggests that "students can benefit from observing the interaction in the group, not only by actively interacting themselves for it may be easier to understand explanations directed to others than explanations directed to oneself" (Webb, 1991, p. 377). This is a significant benefit from collaborative group work as it shows that one need not actively participate in the group to gain benefit from group work. Time does not always allow everyone an opportunity to have a say, but such occurrences need not disadvantage one's learning. "The 'monitoring' feature of cooperative problem solving is often more productive than individual problem solving" (Kroll, Masingila and Mau, 1992, p. 621). Monitoring is an 'active' form of participation.

Another benefit of collaborative learning is that the student is more likely to encounter problems to resolve in the group setting than by working alone. In fact it may be their own problem or problems that are resolved, problems which might not have been exposed in an individual work environment. "Learning requires that existing ideas be challenged and a challenge may occur when a student finds that peers think about a problem in a different way" (CC, 1997, p. 199). Investigations into collaborative learning including those by Johnson and Johnson (1989), Sharan (1990) and Slavin (1990a) have provided evidence of benefits such as:

increased knowledge or skills, increased conceptual understanding,
modified attitudes or motivation, improved communication skills, and
improved social skills as well as evidence that cooperation promotes
self-esteem, increased efforts to achieve, enhanced psychological
health and caring relationships, and the ability to take the perspective

These are all important and positive reasons supporting the adoption of a collaborative learning environment. My study extends such work to include the examination of the students' attitudes to working in such an environment.
Two further findings from research deserve a special mention. The first relates to the effect on high achievers of working in a collaborative learning environment, especially one utilising heterogeneous group mixes as was the case in my study. It is important to record the success of the high attainers since there is a fear among many teachers that grouping such children with low attainers adversely effects the high attainer. The two major findings of this study would argue for the obverse of that (Bennett and Cass, 1990, p. 73).

These findings are often determined by how questions are asked or what is examined in the data, and so there are supportive findings and contradictory findings on this issue. Given the narrow overall range of ability in my class, I am satisfied that the more able students gained as much as any other group during the implementation.

A second research report simply states that a collaborative learning environment can facilitate social and academic growth within the personal development of the students. "Academic achievement and increased social skills can go hand in hand" (Sapon-Shevin and Schniedewind, 1992, p. 27). The reported benefits of working in a collaborative learning environment encouraged me to pursue my implementation plans, and would, I believe, also encourage other teachers to experiment.

**Impact on girls**

As my research takes place in an all girls school I considered it important that findings from studies which had focused on such environments be carefully considered in the development of my implementation. Gwizdala and Steinback (1990, p. 219) found that "female students in a single-sex environment have a more positive attitude about mathematics and their ability in mathematics than their counterparts in the mixed-sex schools". I thought it was important to capitalise on this aspect of the students' profile and build on it. A carefully planned collaborative classroom offers students a "much less threatening environment than the competitive thrust of individual work" (AEC, 1991, p. 4–6), an environment in which the students "can more readily take academic risks" (Rosenbaum, Behounek, Brown and Burcalow, 1989, p. 11), and where "anxiety is less likely to interfere with learning" (LeGere, 1991, p. 171). "Each student has the opportunity to give help and be helped in a non-threatening way" (Artzt and Newman, 1990, p. 449). This highlights the issue of where the control of learning rests. "Cooperative learning puts the responsibility for learning on the learner" (Augustine, Gruber and Hanson, 1990, p. 4). Parker (1992, p. 29) found that "girls are more comfortable in cooperative rather
than competitive learning environments". Such findings supported the implementation of a collaborative learning environment for my class, and I gave the students the responsibility for their own learning through our joint endeavours to enhance their understanding and develop their social skills.

**Constructivism's influence**

Earlier in this chapter I alluded to the strong influence that constructivism has as a referent to researchers and practitioners in mathematics education. In discussing the less threatening and more caring nature of a collaborative learning environment, especially for girls, one hears calls for further research and results from completed projects couched in a constructivist tone. In describing the 'ideal' mathematics teaching learning environment, the National Council for Teachers of Mathematics suggests that "students will perform better and learn more in a caring environment in which they feel free to explore mathematical ideas, ask questions, discuss their ideas, and make mistakes" (NCTM, 1989, p. 69). This statement, and the following one, read very much as 'constructivist' approaches to classroom interaction.

For students to become effective learners of mathematics, they must be actively engaged, want and be able to take on the challenge, persist in effort and take risks. For this to occur the student must personally experience a supportive environment, with mathematical challenges, which promotes and enhances sustained and robust learning (CC, 1998, p. 206)

The matter of risk-taking, making mistakes or exploring errors is a strong benefit found in caring constructivist-oriented and collaborative learning environments. "Students feel safe to make and learn from mistakes" (Duren and Cherrington, 1992, p. 80) and they "find it much less threatening to make a mistake in front of two or three peers than in front of twenty-five or thirty" (Rosenbaum et al., 1989, p. 11). "Using mistakes to effect learning would be better than merely correcting them, and verbal interaction may be the best way to encourage this" (Duffin, 1986, p. 11).

Throughout my study, the group aimed, as a whole class, never to simply correct someone but rather to explain the problem to them, and this was nearly always done verbally. Peer interaction, as encouraged in a collaborative learning environment such as the one I implemented, is "an effective technique for correcting errors" (Amigues, 1990, p. 41). Being able to address the students' meanings was one of the important teacher characteristics adopted in my study and led to automatic student error correction procedures. "Students' ideas need not be considered wrong when compared with the accepted ones of mathematics, but only different" (Solomon,
1994, p. 9). By adopting this somewhat constructivist approach, teachers focus on how they work and talk with their students, aware that "the central position in our minds should not be 'has the child understood what I'm getting at?' but 'have I understood what the child means?'" (Rowland, 1986, p. 28). Thus a constructivist perspective implies a very student-centred approach which a peer interactive collaborative learning environment, as used in my study, facilitated.

**Classroom norms**

Whenever a collective of people is organised into groups to collaborate for a purpose, the groups need to have parameters or 'norms' in place which guide their functioning. "Simply placing students in groups and telling them to work together does not, in and of itself, produce cooperation - and certainly not the higher achievement and positive social outcomes that can result from cooperative learning groups" (Johnson and Johnson, 1990, p. 30). The 'norms' which guided practice within the classroom in my study were modelled on the following:

- that students cooperate to solve problems
- that meaningful activity is valued over correct answers
- that persistence is more important than completing a large number of activities
- and that groups should strive for consensus as they work (Yackel, Cobb and Wood 1991, p. 397).

Norms also existed for individuals including:

- that students figure out solutions that are meaningful to them
- that they explain their solution methods to group members,
- and that they try to make sense of other students problem-solving attempts (Yackel et al., 1991, p. 398).

Such 'norms' were constantly to the fore in the classroom in my study, often in the form of having students realise the value of monitoring their own progress and needs, and to do likewise for their fellow group members. "Social norms are seen to be important contributory factors to rich constructions by children (Lerman, 1996b, p. 3). These 'norms' relate to the "interpersonal and small-group skills that are vital to the success of cooperative learning" (Johnson and Johnson, 1990, p. 30). To collaborate effectively and be productive, "students must be taught these skills and be motivated to use them" (Johnson and Johnson, 1990, p. 30).

My study, implementing a collaborative classroom learning environment, saw these social 'norms' or group work skills being negotiated by myself (as the teacher) and the students during the early days of our school year. Such negotiations are "crucial in establishing the routines and patterns necessary for the smooth functioning of the
class" (Wood et al., 1991, p. 598). Given that the classroom was the focus of my research implementation, it is important to note also that "the norms for classroom interaction and learning can be re-negotiated by teacher and students in such a way that the goals and activities of research and teaching might productively co-exist" (Wong, 1995, p. 27). We found that our classroom social norms were "continually reconstructed in the course of classroom interactions" (Cobb et al., 1992, p. 487; Voigt, 1985; Mehan, 1979) and we also found that "most of the substantive negotiation occurred in the first two months of the year, although norms were continually renegotiated and reinterpreted throughout the school year" (Yackel et al., 1991, p. 400).

Knowing that "cooperative skills and academic skills can be taught simultaneously" (Johnson, Johnson, Holubec and Roy, 1984) encourages a teacher to ensure that the necessary skills are effectively developed. Indeed "the activity of negotiating social norms is less effective when it becomes a separate classroom activity" (Lo and Wheatley, 1994, p. 159) so the 'norms' do not have to be developed in isolation. This is an important facet of a functional collaborative learning environment because social norms should not only be negotiated, but also understood by the students. The rules must be clear and fair to all. It is important to emphasise that in my study, developing a collaborative learning environment incorporated the negotiation of social norms alongside the negotiation of mathematical meaning. "The negotiation of social norms makes possible the negotiation of mathematical meaning" (Lo and Wheatley, 1994, p. 145). All the requisite interpersonal and social skills or 'norms' evolved alongside and assisted in the negotiation of mathematical meaning.

**Talk is cheap and vital**

One of the key features of a collaborative classroom is the discourse or discussion that occurs between participants. "A promising context for the development of interpersonal processes seems to be classroom discussions" especially "where the focus is on the long term processes and where the teacher's role is monitored" (Bartolini Bussi, 1996, p. 16). Without an open forum for communication and the exchange of ideas, such an environment is little more than a physical arrangement of furniture and people. The statement by Huber that "in situations of cooperative learning in small groups, the verbal component of social interaction is of central importance", (1990, p. 517), exemplifies the emphasis which my study placed on the development and encouragement of discussion. "Appropriate mathematical challenge is provided through engagement in mathematical discussion and debate with peers" (CC, 1997, p. 202) "Having students work together discussing problems
and posing questions for each other can be as useful in helping them develop sound concepts as can having them work together to resolve conflicts (AEC, 1990, p. 40-45), while determining "individual understandings, strengths and weaknesses necessitates informal and frequent discourse between teachers and students". This also provides teachers "with the opportunity to give feedback, encouragement and assistance as well as to draw out individual children's thoughts and ideas" (Mousley, Clements and Ellerton, 1992, p. 137). Observations from my study show that considerable discourse occurred in the proceedings of our mathematics lessons, thus facilitating those experiences referred to above.

The teacher has an important role to play developing in students an awareness of the value of discussion in mathematics. Some of the classroom 'norms' for discussion which need to be nurtured and developed by the teacher and the students include:

(a) to seek clarification when the discussion is not clear, (b) to be willing to talk about their own ideas, (c) to listen and respond to other students' ideas, (d) to build on other students' ideas to increase understanding and motivation, and (e) to be sensitive to other students' feelings (Vacc, 1993 p. 225).

The teacher must assist the students to evaluate the effectiveness of their discussions from time to time. Each of Vacc's points listed above were evident in the observations from my study and most were the object of specific development at one time or another.

Discussion not only facilitates learning, it also enhances social skills within a collaborative classroom. "By listening to students' ideas and encouraging them to listen to one another, one can establish an atmosphere of mutual respect" (NCTM, 1989, p. 69). Discussion can alter the focus within the class "from an environment in which students are totally dependent on the teacher to one in which students assume more responsibility for validating their own thinking" (NCTM, 1989, p. 79). To facilitate this change in focus, stimulate discussion and encourage student thought, a teacher may have "to make the class realise they cannot completely trust their instructor" (Lochhead, 1992, p. 551). This can be achieved by failing to provide all of the answers or by not being the font of all knowledge and instead, leading the students to seek each other's counsel as they come to rely more on their group members and themselves. Discussion within groups encourages and enables students "to apply previously learned knowledge to mathematical situations" (Vacc, 1993 p. 225).
Discussion allows students to "get information they personally do not have" (AEC, 1990, p. 19; Hart, 1985, February) and receive "evaluative feedback from their peers and their teacher to help identify gaps in their own understanding" (Vacc, 1993 p. 225). Discussion reveals that not everybody shares our viewpoint, so through our interactions with other people we are able to "constantly adjust our understanding and interpretation of phenomena" (AEC, 1990, p. 19). "Explaining something to a peer usually leads to seeing things more clearly and often to spotting inconsistencies in one's own thoughts - a process which provides a wonderful opportunity for learning" (von Glasersfeld, 1993, p. 30; AEC, 1990, p. 19). By listening to the points of view of others, determining our level of agreement and resolving our differences we may reach partial consensus within our group or class, although "it is not necessary for each person in a group to agree with the consensus" (Tobin, 1990, p. 32). "The interactions may negotiate a common view of the task, or they may not" (Forman, 1995, p. 551).

Another vital role for discussion within groups is its value and power in enhancing students' collective understanding of the mathematical processes and procedures being examined. "Students may understand better than their teacher what other students do not understand" (Vedder, 1985) and be able to "conceptualise the information in ways that more effectively communicate" information for each other (Burbules and Linn, 1991, p. 236). Furthermore, because students share similar language, they "can translate difficult vocabulary and expressions and use language that fellow students can understand" (Noddings, 1985) and they can "provide help immediately when a peer has difficulty" (Webb, 1991, p. 369). "In this case the teacher utters a voice that represents the mathematical culture: the perspective on the object that is introduced by the teacher is usually different from the ones that are introduced by the pupils" (Bartolini Bussi, 1996, p. 17). All of these features illustrate the value of the group over the teacher when collaborative learning is occurring. However, while the students often choose more understandable (to them and sometimes even to the teacher) language with which to describe things, the ultimate responsibility rests with the teacher to introduce and develop the more formal language of mathematics to the students.

Another discussion skill or 'norm' which a collaborative classroom must develop involves valuing explanations over answers. To achieve this skill, the teacher can encourage the students "to question one another about their work" (Thomas, 1992, p. 1). In my study I was constantly encouraging the students to engage in elaborate and detailed explanations of what they were doing whenever they communicated with their fellow group members or with the class. This was designed to promote optimal
and effective student participation in the group work. By making public one's thoughts and ideas "it becomes possible for others to critique and shape one's understanding, something that cannot be done effectively if only the results are visible" (Resnick, 1987, p. 432). "Giving explanations requires a greater depth of understanding that goes beyond that required merely to state an answer" (Artzt and Newman, 1990, p. 449). Students quickly learned that discussions were not avenues for providing correct answers, but rather vehicles by which all students could challenge solutions and answers. "The teacher demonstrated that if the children accepted the obligation of expressing their mathematical understandings then the teacher, as an authority, was obliged to protect them" (Cobb et al., 1991a, p. 166).

The students in my study soon realised that discussions were used to negotiate a class consensus on solutions and methods. The students certainly developed 'support' techniques for the various phases of their work, namely interpretation, process, or providing solutions. It was an aim of my study to 'empower' students to believe they had the ability, the permission and sometimes an obligation to interact with their peers and their teacher as they did their work.

In supporting so enthusiastically the role of discussion within the collaborative classroom, it is important to alleviate concerns which may arise when discourse 'erupts' among the students. The principal issue stems from the purpose for which the discourse is undertaken, as many teachers would imagine that much of the discussion is 'off-task'. In fact when Thomas (1994) "analysed interaction patterns of New Zealand students working collaboratively she found that, to the surprise of the teachers in her study, 91% of interactions were related to the task" (Higgins, 1995, April, p. 3). The value and benefits of discussion far outweighs any possibly negative effects such interactions may yield. "Talking about mathematics means becoming actively involved in learning mathematics" (Artzt and Newman, 1990, p. 449). Lipman (1991) reported that Vygotsky "identified the most common cause of miseducation: failure to convert the classroom into a community of discursive inquiry". Such a failing never arose in the class in my study for we had significant amounts of discursive inquiry going on most of the time.

Many times in my observations, particularly towards the end of the implementation, I had remarked on how the students were able to take over the discussion and negotiate the results among themselves. I was often reduced to the role of recorder. As the year progressed, the teacher's facilitation of discourse provided opportunities for the students' incorrect answers to be resolved by the students themselves during the course of the discussions. As student's mathematical thinking continued to develop, they were able to engage
in more complex and concise explanations and justifications of their solutions (Wood et al., 1991, p. 605).

As the students developed these skills, disputation became more frequent as their confidence to question others grew. This was even evident in the more usually withdrawn students. "The most critical part of the process occurred in the follow-up sharing between groups and the teacher" (Jones and Thornton, 1993, p. 25). This sensitivity comes with practice which further supports the idea of developing these skills and doing this type of research in the classroom. A teacher has to develop the skills of knowing when to intervene, listening to students' explanations, understanding the students' thinking and building on this, and of balancing individual and social knowledge. I became a facilitator, so to speak, allowing the students to get on with the discussion of concepts, negotiation of meaning and development of understanding, collaboratively in their groups.

The teacher also changes

As teachers use their reflections to plan new activities that extend and challenge students' current ideas they invoke a recurring cycle of activity, reflection and further activity. "The awareness of teachers is also changed by the experience of interaction with their students" (Crawford, 1996, p. 44). This represents a 'snapshot' of Vygotsky's notion of the 'zone of proximal development', and of the "classwide" (Hedegaard, 1990) 'zone of proximal development'. This cycle typifies the practices found in my classroom during the implementation of the environment designed for my study. This Vygotskian approach is often performed 'insitu' by teachers as they react to the unfolding lesson and the representations of understanding which the students verbalise during the course of discussions. As the students developed skills in critical review of each others work they became happy with the 'publicness' of their knowledge and their work processes. By working in groups students were able to see a 'bigger' picture than that of only their own understanding.

Collaborative learning classrooms not only require the development of a caring environment, social 'norms' and discursive skills for the students, but they also require that the teachers' behaviours develop accordingly to ensure that the environment maximises opportunities for the participants. In light of the previous section on the importance to a collaborative classroom of discussion it is clear that "one of the teacher's responsibilities is to help children learn how to engage in collaborative dialogue about mathematics" (Wood and Yackel, 1990). This is why, in my study's observations, there are many instances of my facilitating group discussions as I moved around the room. This highlights a further role for teachers
wherein they must facilitate the students' knowledge advancement through the mediation of the language the students use and the language used by society or the global mathematics community. This process models "the development of interpersonal processes" (Bartolini Bussi, 1996, p. 16), and the acquisition of concepts and knowledge from individual to group to class to school to community.

"Teachers must be willing to entertain suggestions from students and suspend judgment about their ideas" (NCTM, 1989, p. 245) thereby "remaining open to creative student solutions" (Lochhead, 1992, p. 551). As the teacher in this study, I often accepted and worked with incorrect solutions until such time as the students picked up the errors and corrected them. "To learn from a challenge or conflict, the student must recognise it, see errors as a useful source of feedback" (CC, 1998, p. 207). Sometimes this meant that I had to be the one who stopped and pondered the direction that the problem was taking so as to encourage a more critical review of the process by the students and hopefully their detection of errors. "One can conduct a lot more discussion about errors than about correct answers" (Stigler, 1988, p. 29).

"Helping students evaluate one another's suggestions and reflect on them" (NCTM, 1989, p. 245) is a vital skill for a teacher working in a collaborative classroom to develop. This is modelled by the teacher "often thinking aloud so that the mathematics is more accessible" (Edmunds and Stoessiger, 1990, p. 31).

One key attribute for teachers to master in this situation involves not giving only answers when discussing activities. "The teacher's role is to be a guide, and to support and suggest when questions arise, not answer the questions" (Mann, 1990, p. 34).

When interacting with the students, either in groups or with individuals, the teacher will be asking questions which may prompt the student to clarify, to predict, to develop further, to look for alternatives. By asking these questions the teacher models the questions that the students will ask later, either of themselves when refining their work, or of others during a sharing time (Edmunds and Stoessiger, 1990, p. 31).

These were the teacher behaviours I adopted within my study and observed during its implementation. In particular, one frequent observation throughout the implementation stage related to my movement patterns around the classroom. This was to be expected since "teachers beginning group work with their classes will find that they (the teacher) are moving around the room constantly" (EDWA, 1984, p. 40). Another expectation was that "the cooperative activities would supplement but do not replace direct instruction" (Slavin, 1990b, p. 1). There was certainly plenty of
good old-fashioned instruction still occurring but I was conscious (and sometimes self critical of excess) of keeping this to a minimum.

Some more 'Cons' and 'Pros'

Some other points are worth noting.

There is a strong tendency to consider mathematics as an 'ill-structured' domain for children who are constantly at the 'frontier of knowledge' as they progress through the Year 8 syllabus. In order to become socialised to the complex mathematical culture of our societies, they need opportunities for sharing meanings and for debating, which are better practiced and learned through the social context of group discussion in which there is room for social support and collective reasoning (Pontecorvo, 1990, p. 21).

"Ill-structured" means new and difficult to do due to lack of experience or previous exposure. This describes most of the work in the Year 8 mathematics course followed for my study. Another issue is that "cooperative learning is one of many successful teaching methods, but no teacher should rely on it; students and teachers need variety" (Sutton, 1992, p. 66). This need for variety is highlighted in my study by examples of units in which the whole class struggled to follow the concepts when studying as a group. This may have been because the unit was not suited to open forum discussions and the group work-based approach which we used nearly all the time.

While some of the content in a mathematics course may not be suited to a collaborative environment, one of the benefits of working in a collaborative classroom, which has not yet been mentioned, is that of role-reversibility between the students and the teacher. In a typical traditional mathematics lesson at school "teachers give directions and students nonverbally carry them out; teachers ask questions and students answer them and most importantly, these roles are not reversible" (Forman and Cazden, 1985, p. 329). However, in collaborative classrooms engaged in peer interaction, "roles may be easily reversed, directions may be given as well as followed and questions both asked and answered" (Forman and Cazden, 1985, p. 329). This places significant value on peer interaction in a student's development.

Noise is rarely viewed as a benefit to a working environment, however it can be better understood when studying a collaborative classroom. Rogoff and Wertsch found that students progressed through stages of play, peer and teacher interaction
when engaged in problem solving (1984, p. 61-62). Each of these stages played a part in the students' acquisition of the problem, their discussion of it and their subsequent solution of it. The peer activity is particularly valuable as it allows students to discover the task. Play activity is useful as a mediating device from which the students begin the task (noise stage). They require teacher interaction when negotiating and resolving newly acquired knowledge or concepts, or in establishing the correctness of their interpretation of what the task requires. The students stop playing when the novelty wears off and they cease their peer interaction when their work is done. "The excitement of small group talk does at times result in noise. As students become more familiar with working in small groups they work more quietly" (EDWA, 1984, p. 49-50). Discussion and helping sometimes produces 'noise' but as my observations show this developed into what I called productive noise and could be easily managed by the teacher so as to ensure it did not become disruptive noise. "The findings also "provide evidence for the close relationship between context (activity), and its distinctive effects on (verbal) actions" (van Oers, 1998, p. 485).

One final point to note is the role of the influences on the students' learning which occur outside the classroom. These are not as easily managed by the teacher. We must be aware that "no matter how good a job a teacher does at creating a cooperative community within his or her own classroom, much of this work can be undone when students move to classes with competitive or alienating environments" (Graves, 1992, p. 63). The students in my study's class did have many other teachers and many other learning environments to experience within any given day or week.

Theoretical links

Much is made in this study of the importance of the theoretical positions which informed and guided the development and implementation of our collaborative peer interactive classroom learning environment. These next few passages highlight the links between the use of such an environment and the Vygotskian (and to a lesser extent, constructivist) frameworks that moulded the practice and procedures used in the classroom. "Vygotsky's strategy was essentially a cooperative learning strategy. Under these circumstances, children could create a 'zone of proximal development' for each other. Vygotsky saw peer interaction as fostering self-regulation, self-direction and self-control" (Newman and Holzman, 1993, p. 77). Thus a clear association can be drawn between Vygotsky's theoretical approach to classroom learning and the use of collaborative classroom environments. The steady increase in the pace and level of difficulty which was indicative of the mathematics course
covered in my study can also be seen in Vygotskian terms as "operating in the zone of proximal development" (Hedegaard, 1990). "If the instruction is 'good' in Vygotsky's sense then it will lead to development of the students, so the demand of the courses must increase as the year progresses" (Grayson, 1996, p. 999). In embracing a constructivist perspective, this study situated itself within a socio-cultural context for learning which views "the body of mathematical knowledge as being represented by a socio-cultural historical construction" (Schmittau, 1993, p. 33), a position which links a constructivist perspective with a Vygotskian approach. The 'socio-cultural historical construction' is also referred to by researchers as 'taken-as-shared', or community knowledge.

The fallibility of research

In his synthesis of collaborative research, Slavin found that "study durations were at least four weeks, with a median length of ten weeks" (1988, p. 32). Ten weeks is approximately one school term, but what happens if the study is longer? The present study lasted for over 40 weeks, although this thesis only reports the first 20 weeks. Interestingly, most studies testing for, and verifying, long-term effects from collaborative learning environments have done so over relatively short periods of time using a brief intervention and a much delayed follow-up assessment. For example, Duren and Cherrington (1992) used a four week intervention with a follow up test three months later for the specific skill(s) supposedly taught. How valid are these sorts of studies? They operate over a very limited time period and the students are subjected to a limited intervention. The students involved, both experimental and control groups, are supposed to be developing knowledge subject to experimentally specified class conditions, but we all know that those same students mix socially and academically outside of the particular subject under experiment. Pederson's (1992) intervention lasted only four weeks, with class intervention dedicated to the actual experiment occurring for only six out of the twenty days. Hence the validity that one group did x while another did y is surely compromised by the out of class communication which was certain to have occurred. In Pederson's case, such issues are further complicated by the fact that the students did the same objective test three times as the pre-, post- and delayed post-test. This illustrates how some researchers have had great difficulty embracing the impact and effects of the whole school learning environment.

"In recent years educational researchers have realised that it is almost impossible to say that 'treatment A' is better than 'treatment B', in part because no two classrooms and no two students are exactly alike" (Lambdin et al., 1994, p. 38). This
observation certainly applies to my study where the implementation was not experimentally controlled. Students were either involved (my class) or not (other classes) and the effects on any particular student who was involved cannot be compared to that very same student having not been involved. While dominantly quantitative investigations are able to 'statistically' control their experiments, a mostly qualitative investigation, with a methodology like mine, cannot do so.

My collaborative peer interactive classroom model

My view of collaborative peer group interaction contrasts with the Slavin model (1991) and other similar approaches (e.g. Johnson and Johnson, 1991) where groups are used as a management technique to motivate time on task, and ensure the mastery of facts and procedures. However, those of us implementing a more Vygotskian or genuinely collaborative approach, must still realise that facets of those other models, such as developing intra-group cooperation, have a role to play in our interventions. A model for collaborative learning which corresponds to that utilised in my study involves five-stages or processes:

1. INPUT - Teacher, other visual means, textbook.
2. EXPLORATION - make an initial exploration of the information.
3. RESHAPING - work with the new information in some way.
4. PRESENTATION - learner is required to show what has been learned.
5. REFLECTION - Asking students to reflect upon what and how they have learned (EDWA, 1984, p. 7-9).

It is necessary to provide a period of time within which this reflection can occur. This applies to any and all type of pedagogical practice and is not just specific to those influenced by the paradigms at work in my study.

The above model has additional features within my study. My INPUT stage emphasised input from the students, which I saw as important as the other sources, and my REFLECTION stage benefited the teacher as well as the students. "To reflect is to engage in a conversation with oneself. In such a conversation, one's ideas can be reconsidered in the light of previously joint activity with teachers or peers" (EDWA, 1984, p. 7-9). Asking students to reflect upon what they have learned helps them to understand its content. They need to be taught to "reflect upon what they have found from their mathematical work, thinking about what did and did not work and why, and how it connects to other mathematical concepts and processes" (CC, 1997, p. 202). Asking students to reflect on how they have learned helped them to understand how they can continue to learn, and increased their sense
of involvement in the learning process. Asking students to reflect upon what and how they have learned helped the teacher to evaluate the learning and the learning programme, and to base further activities on the information gained.

All this reflecting requires considerable discourse within the class which results in "the noise level being higher than most classrooms because students are talking about activities with their peers. However, the noise level always stays within reasonable bounds, the talk is generally about mathematics and is not distracting to others" (Cobb et al., 1991a, p. 159). As the environment developed in my study I found I was often focused on the noise level within the class and it took a considerable time for me to accept that amount of noise. One feature that leads to such acceptance is that if the teacher listens to what the students are saying he or she soon discovers, depending on the appropriateness of the task, that the students are nearly always engaged in discussion about the mathematics they are doing and not, as one might first suspect, other 'social' aspects of their lives.

Students like-collaborative group work because such an environment promotes a non-threatening caring ethos within which learning can occur. "Students who know they can depend on other group members for help and support do not feel the anxiety often experienced by those who do not understand the work" (Artzt and Newman, 1990, p. 452). Collaborative learning combines "intrinsic motivation for learning mathematics" with enjoyable social aspects where students can "form new friendships and learn to appreciate differences in ability, personal characteristics and of opinion. Learning together is fun, being part of a group is exciting" (Artzt and Newman, 1990, p. 452). All of the above outcomes are worthy of pursuit by any teacher for the benefit of their students. One of the things to avoid, that Slavin and others advocate, is the testing of the individual and the comparison of their scores on a combined group basis which, I believe, has the potential to make a group feel it is disadvantaged should it contain a less able student, a situation which can then lead to isolation and animosity within that group. So the types of assessment employed and the ways assessments are used are critical to the group ethos within the class as the collaborative environment is being established. Assessments also have an impact on whether or not the prime motivation to learn is intrinsic, as suggested above, or extrinsic, as suggested by those who advocate a 'rewards' based approach.

"Assessment practices in secondary schools require students to demonstrate their individual competence" (EDWA, 1984, p. 7-9). This assessment practice makes it critical that the students be given individual time when involved in group work and serves to illustrate how group work is not an approach which can be utilised within
the mathematics classroom 100% of the time. Each student has to learn to cope on their own while at the same time having the advantage of working collaboratively whenever they need to. Assessment practices based on the individual are likely to be around for a long time yet, and implementers of collaborative environments such as mine need to be aware of this and to be realistic by taking this into account when designing pedagogical practices. My study strove to achieve a balance between the 'devil' of assessment along with school procedures that we were obligated and committed to, and the 'deep blue sea' of developing genuine collaboration.

In such a collaborative learning environment, the tasks students are engaged in by their teacher are almost always beyond their ability, unless the tasks are of the drill and practice variety. The teacher interacts with and observes the students to discover the ways they approach the solution of the problems set. By working in collaborative groups, such an observational approach is made much simpler because the teacher can monitor the development of the students' techniques of solution within the context of a social environment which has been established for that purpose. The end result is a discourse which all participants are able to understand and which outlines effective methods (those 'hidden processes') of solution for the given problems. "The role of the teacher in these social contexts is to provide the necessary guidance, mediations, in a Vygotskian sense" (Moll, 1990, p. 8) and to develop in the student the ability to "internalise" (Wertsch, 1985) the learning process so they can carry it beyond the classroom. "When the school child solves a problem at home on the basis of a model that he has been shown in class, he continues to act in collaboration, though at the moment the teacher is not standing near him" (Vygotsky, 1987, p. 215-216). Creating independent learners is perhaps the greatest benefit which a collaborative learning environment can produce.

**Summary - Collaborative Group Work**

The contemporary issues in mathematics education research addressed in the preceding sections, especially the calls for continued study into collaborative learning environments, strongly influenced my thoughts in developing and implementing my classroom intervention. Matters concerning valuing the individual, achievement, creating a non-threatening environment, developing academic and social 'norms' as well as effective discourse procedures, changing teacher behaviours, types of motivation and typical characteristics of collaborative learning all played a role in affecting the way I approached the learning and teaching processes within my class. Issues of noise, discussion, valuing student contributions and the powerful role of peer interaction are all addressed in the literature and this
study reveals additional and complementary observations relating to these and other factors found within my collaborative classroom environment.

Like many teachers however, research issues such as these need not have any bearing on my teaching. All too often research is couched in terms which inhibit their translation into the practical environment and unless teachers make a deliberate effort to seek out such information much is lost to them. What motivated me to seek out the theory reported above and to attempt to implement relevant aspects of mathematics education research within my practice was my earlier exposure to alternative perspectives on the learning-teaching process (Ireland, 1986). These alternative perspectives were not evident in my teaching practice prior to this current implementation.

In the next section I examine the works and related literature of the most significant of these alternative perspectives, that of Lev Vygotsky.

VYGOTSKIAN PERSPECTIVES

Vygotsky's role within mathematics education

Vygotsky's work began over 85 years ago but it has only been examined closely in education for the last 25 years or so and in mathematics education for the past 15 years. "The theory of Vygotsky and his colleagues offers great potential for research in education" (Lerman, 1996b, p. 5). As researchers turn to these ideas they begin to see that many of the multitude of issues Vygotsky addressed are relevant to contemporary mathematics education theory and practice. Vygotsky's emphasis on a socio-cultural and socio-historical approach to learning, his ideas about concept development, his notion of the 'zone of proximal development' and more are all now receiving the attention of modern mathematics education researchers and of researchers in related fields. "The cultural-historical orientation can be encapsulated by referring to Vygotsky's seminal work" (Boero, 1999, p. viii). The influences on, and the results of the findings from this modern Vygotskian research are now evident.

Vygotsky's socio-cultural position saw him emphasise the role of 'out of school' learning on a student's development. This has become an area of investigation for modern mathematics education researchers. "Children begin their mathematical experiences at home" (AEC, 1991, p. 1). By enhancing teachers' awareness of this
notion, the Australian National Statement on School Mathematics aims to increase the value of a student's prior knowledge within the classroom environment.

It is clear that students develop their own (informal) mathematical knowledge even before they receive any formal training in school. They do this because it is personally meaningful, interesting, and useful to them. Even after they begin school students continue to rely on their informal mathematics (Baroody and Ginsburg, 1990, p. 51).

As teachers, we should be endeavouring to extend the natural learning environment to ensure that the "student's learning or cognitive restructuring occurs in social contexts as he or she participates in social interactions with both the teacher and his or her peers" (Cobb, Wood and Yackel, 1991b, p. 24). "Pedagogically, in mathematics teaching this might mean much more use of the stratagem of 'get into groups and see if you can nut it out for yourselves' rather than the traditional diet of exposition, example, exercise and test" (Boomer, 1986, p. 5). Peer interaction was one of Vygotsky's priorities in describing the teaching-learning process, for such "group work allows spontaneous concepts to be brought forward without penalty" (Boomer, 1986, p. 5). This was one of the reasons why I chose to develop a collaborative peer interactive classroom learning environment. "Cooperative learning capitalises on the powerful influence of peer relationships" (Artzt and Newman, 1990, p. 448), and on a student's learning potential. Students collaborating in groups, "learning material for the first time, may be more aware than their teacher of what other students do not understand" (Vedder, 1985; Vygotsky, 1981) and are able to give "explanations that focus better on their fellow students' misconceptions" (Webb and Farivar, 1994, p. 370). Such explanations and understandings arise because "students share a similar language, so they can translate difficult vocabulary and expressions and use language that fellow students can understand" (Noddings, 1985). The reference here to Vygotsky has been made by others, particularly in regard to the notion that students use more appropriate language when talking among themselves about concepts compared to the teacher's potentially more formal language system. An observation frequently made in my study showed that through my monitoring of the groups' communications, I was able to determine the language levels being used by the students, and thus I was able to engage in discussions with the students using an appropriate language level.

Researchers working within a Vygotskian perspective link discourse among students with conceptual learning and higher order thinking (Cohen, 1994, p. 3) and define productive groups as those that are engaged in a high level of discourse (Noddings, 1989). To Vygotsky, the process of concept development is "a phenomenon that
occurs as part of the educational process, a cooperative process" embodied in the interactions between and among teachers and students (Vygotsky, 1987, p. 169). In such interactions students are encouraged to challenge each other's thinking. In doing so "they invoke development of the zone of proximal development by causing each other to think about their thinking, that is metacognitive processing" (Goos and Geiger, 1995, July). In developing metacognitive processes students "have ideas and assess their own ideas, ask others to assess their own ideas and examine and discuss the ideas of others" (Goos and Geiger, 1995, July). This is a pattern of learning encouraged by a collaborative environment, such as the one implemented for my study, one which enhances the development of metacognitive thinking processes.

In the development of such a classroom environment the teacher attempts a gradual handing-over of the responsibility for task completion to the students, encouraging them to work and think collaboratively within their groups as well as individually. In such a situation "the teacher appears to be more easily able to moderate the influence of the social behaviour on achieving the mathematical learning outcomes, a role closer to a Vygotskian approach" (Higgins, 1995, April, p. 9).

There is evidence in my study of how I guided the students in the development of the new material, and as they displayed increasing levels of mastery I reduced the levels of guidance until the students were operating independently of me, either in their groups or ultimately on their own. Thus in my study, my role seemed to model a Vygotskian approach and brought together in a practical context several of Vygotsky's principal ideas. Practitioners, such as myself, and "researchers have become increasingly interested in the relationship between the zone of proximal development and peer interactions in educational settings" (Jones and Carter, 1994, p. 604).

Mathematics education is a part of the greater community of education which embraces and is informed by educational psychology and by broad based theorists such as Vygotsky. "The development of instructional methods and of matters concerning the organisation of teachers' and pupils' time is impossible without utilising the achievements of psychology (Wilson, 1981, p. 76) and Vygotsky is certainly now viewed as a principal player in this field. "Vygotsky has clearly made a profound contribution to our understanding of intellectual development, not the least by alerting us to the crucial role of social interaction" (Cobb, 1989, p. 40). "Several theoretical constructs of Vygotsky's have potential implications for research in mathematics education" (NCTM, 1980, p. 178-180).
"Vygotsky's systemic view of human development and consciousness mediated through action in a cultural context was formed in another era of social change. In the present era, another time of rapid change in the nature and purpose of human activity, his insights may be valuable as a lens through which to view modern dilemmas and challenges" (Crawford, 1996, p. 60).

However, paying all this homage to Vygotsky and his theories must be kept in balance as "it would be naive to divorce his work from its socio-historical setting and assume that it provides ready made answers to our socio-historically specific problems" (Cobb, 1989, p. 40). So we must take his theories and test them within the modern context to verify or modify them accordingly - for example, use social interaction but do so in a constructivist collaborative learning environment.

Vygotsky says...

For teachers, one of the strongest attractions to Vygotsky's work is his emphasis on the importance of instruction in the process of child development. Contemporary research of Vygotsky's time kept instruction and development separate, and research focused almost exclusively on development. Vygotsky's unique recognition of the need for research into these relationships led to the conclusion that "research has shown that instruction always moves ahead of development" (Vygotsky, 1987, p. 206), further strengthening his theoretical position with the practical experiences of teachers such as myself.

"A relevant feature of the Vygotskian approach is the emphasis on interpersonal processes as a basis for intrapersonal processes. Interpersonal functioning, that appears between people and may be used to determine the zone of proximal development for individuals, is a precursor of intramental functioning that appears within individuals. Hence learning cannot be separated from teaching". (Bartolini Bussi, 1996, p. 14-16, italics in original).

The instruction we provide to our students leads their development and acquisition of higher concepts within the field being studied. To Vygotsky, instruction was a key component in a child's development. Theories such as Vygotsky's, which place significance on instruction and relate this to child development, deserve the attention of every classroom practitioner.

If we value what we as practitioners do in our classes then our methods of instruction can benefit from incorporating some of Vygotsky's ideas, for his research has shown that "instruction of the pupil in new concepts is not only possible but may
actually be the source for a higher form of development of the child’s own concepts, particularly those that have developed in the child prior to conscious instruction” (Vygotsky, 1987, p. 171-2, italics in original). With this statement, Vygotsky extends the role of instruction from one of introducing, nurturing and developing 'scientific' concepts to also include extending and enriching the child's 'spontaneous' concepts.

We can see the emphasis Vygotsky placed on instruction and how this focuses on the development of 'scientific' and 'spontaneous' concepts. We also need to understand the relationship between 'scientific' and 'spontaneous' concepts and how they interact.

The development of scientific concepts begins with the verbal definition. As a part of an organised system, this verbal definition descends to the concrete; it descends to the phenomena which the concept represents. In contrast, the everyday concept tends to develop outside any definite system; it tends to move upwards toward abstraction and generalisation (Vygotsky, 1987, p. 168, italics in original).

These concepts move in opposite directions and operate as attractors and reinforcers of each other. Greater awareness of 'scientific' concepts strengthens 'spontaneous' concepts while improving and enhancing 'spontaneous' concepts leads to greater understanding of 'scientific' concepts.

"By spontaneous concepts Vygotsky meant concepts that are acquired by the child outside of the context of explicit instruction. Because Vygotsky explicitly acknowledged the role of adults or peers in the formation of these so-called spontaneous concepts he preferred to call them 'everyday' concepts, thus avoiding the idea that they had been spontaneously invented by the child. By 'scientific' concepts Vygotsky meant concepts that had been explicitly introduced by a teacher at school. Ideally such concepts would cover the essential aspects of an area of knowledge and would be presented as a system of interrelated ideas" (van der Veer and Valsiner, 1991, p. 270).

"Scientific concepts have their foundation in everyday concepts. But as soon as the scientific concepts have been mastered they will start to transform the child's everyday concepts, bringing these to a higher level of understanding" (van der Veer and Valsiner, 1991, p. 274). "Scientific concepts are always included in a coherent conceptual system, that is connected with a cultural tradition, hence they are acquired through instruction" (Bartolini Bussi et al., 1999, p. 70). Vygotsky's ideas
on the role of instruction, the development of 'scientific' and 'spontaneous' concepts and the relationships between these leads us to consider in more detail his concept of the 'zone of proximal development', for as Luria states in his afterword to volume one of Vygotsky's Collected Works, "Vygotsky's concept of the zone of proximal development is among his most productive ideas" (Luria - afterword, in Vygotsky, 1987, p. 367).

The 'zone of proximal development'

According to Simon (1987, p. 611-612), Vygotsky called this idea the "zone of next development" (Vygotsky, 1963, p. 31) and defined it as "the divergence between the level of performing tasks which are accessible under guidance with adult help, and the level accessible to independent activity" (Vygotsky, 1963, p. 31). The concept of the 'zone' evolved from Vygotsky's attempt to define the relationship between learning and development "at school age" (Vygotsky, 1963, p. 31). The concept of the 'zone' has been through multiple interpretations and the end product, as Simon points out, is "not the Vygotsky formulation at all" (Simon, 1987, p. 612). In a previous publication Simon and Simon provided the following translation: "zona blizhaishero razvitia = zone of (next) or potential development" (Simon and Simon, 1963, p. 27). Unfortunately other researchers, translators and editors expanded on this. For example, Rogoff and Wertsch assert that "the literal translation of zona blizhaishero razvitia is zone of closest or nearest development" (Rogoff and Wertsch, 1984, p. 1, italics in original). In a previous study I utilised a 'primitive' form of definition for the 'zone of proximal development' which I derived from Vygotsky's 1978 work, Mind in Society. "The zone of proximal development is the distance between the actual developmental level and the level of potential development" (Ireland, 1986, p. 20).

A child's actual developmental level defines functions that have already matured - the end products of development. The 'zone of proximal development' defines those functions that have not yet matured but are in the process of maturation, functions that will mature tomorrow but are currently in an embryonic state (Ireland, 1986, p. 21).

According to Moll (1994, p. 340) such interpretations of the 'zone of proximal development' occur frequently in educational research. Moll calls these maturing functions "the 'buds' or 'flowers' of development rather than the 'fruits' of development" (Moll, 1994, p. 340). A more interesting definition from Moll's perspective is "the actual developmental level characterises mental development retrospectively, the zone of proximal development characterises mental development

All of these definitions are describing the same phenomena as observed by Vygotsky in his research. Like others before me and no doubt some who follow, I have tended to adopt the definition which best describes, or best fits with, the phenomena I have been studying. Throughout this study my perspective had been informed and influenced by all that I had read. I preferred the term 'zone of next development', for this gave me (the teacher) a precise mental picture of the term. The use of 'next' or 'proximal' did not concern this study as I perceived either phrase to be acceptable, although 'next' is probably an easier term to interpret in the context of development. The 'zone of proximal development' lies between the actual and potential levels of development and contains those mental functions which are in the process of maturing. These are the 'next' mental functions to emerge and mature in the student's development. The actual developmental level marks matured mental functions, and the potential developmental level indicates those mental functions which can be exhibited with assistance. The actual level of development is a 'material' situation and one which is made up of concepts which have been internalised, whereas the potential level of development exists as a result of the mediation by others through social interaction. The process of 'evolving' through the social to the internalised then on into more social interaction and so on is what makes up completed developmental cycles which give rise to the 'zone of proximal development'. The word 'proximal' does little to illustrate such meanings. However, in deference to the overwhelming majority of reported research, which uses the phrase 'zone of proximal development', or ZPD, I shall, from this point on, use the word 'proximal' instead of next.

Vygotsky's thoughts

Vygotsky formulated his theory about the 'zone of proximal development' in his research on learning and development "at school age" (Vygotsky, 1963. p. 31). In school, the child receives instruction in what is accessible to him in collaboration with, or under the guidance of, a teacher. This is a fundamental characteristic of instruction. Therefore, the zone of proximal development, which determines the domain of transitions
that are accessible to the child, is a defining feature of the relationship between instruction and development (Vygotsky, 1987, p. 211).

The 'zone' is not static but highly dynamic and as such the student moves through, forwards, backwards and within their 'zone of proximal development'.

What lies in the zone of proximal development at one stage is realised and moves to the level of actual development at a second. In other words, what the child is able to do in collaboration today he will be able to do independently tomorrow (Vygotsky, 1987, p. 211).

Thus Vygotsky's investigations into learning and development may be viewed as drawing towards recognition of the important function of having students work collaboratively.

An essential feature of learning is that it creates the zone of proximal development; learning awakens a variety of internal developmental processes that are able to operate only when the child is interacting with people in his environment and in cooperation with his peers (Vygotsky, 1978, p. 90).

Old 'zone of proximal development' - New 'zone of proximal development' as interpreted by others

It is not only the writings of Vygotsky which influenced development of the theoretical underpinnings of my study. Several other researchers working within Vygotskian perspectives have influenced my work. It is important to remember however that just as my perspectives are interpretations of Vygotsky's translated works, so are the perspectives of others (some of whom interpret direct from the Russian writings). In the next section I attempt to explicate those ideas, terms and definitions of other researchers which influenced the developing theoretical base for my study. The literature shows two particular lines of interpretation of Vygotsky's notion of the 'zone of proximal development'. These exist either side of the publication of volume one of Vygotsky's Collected Works in 1987, although not all authors can be so easily classified.

Many authors "favour instruction within Vygotsky's zone of proximal development" (Brown, Bransford, Ferrara and Campione, 1983) where a child who has "only partially mastered a task can participate in its execution with the assistance and supervision of an adult or more capable peer" (Rogoff and Wertsch, 1984, p. 33). Working on only partially-mastered tasks, and doing so successfully because of the help of others, would be considered normal classroom practice by many teachers. Several authors see Vygotsky's 'zone of proximal development' as "the best measure
of development" (Sutton, 1983), "which can determine not only initial competence, but also potential for intellectual progress" (Bryant, Brown and Campione, 1983). Others see the valuable role of the 'zone of proximal development' to be its potential to allow students to solve problems while participating "at a comfortable but slightly challenging level" (Rogoff and Wertsch, 1984, p. 33), reinforcing the non-threatening aspects of a collaborative classroom learning environment.

The 'zone of proximal development' is not a fixed quantity. "It is quite conceivable for a child with a narrow zone of proximal development in one domain to have a broad zone within another" (Brown et al., 1983). Within a class setting students' 'zones' can overlap and the degree of overlap can vary. I would say that "teaching to a group of children whose zones overlap only in part" (Forman and Cazden, 1985, p. 324) benefits the students. By group, Forman and Cazden are typically referring to a 'dyad'. We also need to consider the more versatile arrangement of a group of 3, 4 or 5 students. Research such as that reported above often implies one-on-one interactions or at most one small group to the teacher interaction. The theory Vygotsky expounds needs to be applied to 'real' classroom situations as in my study. The researchers above, like so many others, are probably reporting on 'laboratory'-type research, as distinct from 'classroom'-type research. Most teachers do not work 'one-on-one' and need to look instead at how they can turn 'many-to-many' to their advantage. Overlapping 'zones' within groups is one such way, but 'zones' are dynamic and continually changing, so overlapping 'zones' are but a snapshot, frozen in time, of the dynamic reality. "Guidance within the zone of proximal development is bi-directional because the learner's changing task performance must guide the teacher's instruction as much as the teacher's actions guide the learner" (Brown et al., 1996, p. 65). Similarly, relationships between 'zones' change as classroom topics change due to the prior experiences of the students. Ann Brown imagines such classrooms as:

enculturating multiple zones of proximal development. Within the multiple overlapping zones, students navigate by different routes and at different rates. The push is towards upper, rather than lower, levels of competence. These levels are constantly changing as participants become increasingly independent at successively more advanced levels (Brown, 1994, p. 7).

I, along with Brown, am one of the few researchers who to date have considered the concept of multiple 'zones of proximal development'.

In describing the type of classroom which I endeavoured to develop, I found the work of Hedegaard (1990) most influential and helpful. Hedegaard's research goal
was to "create a collective, classwide zone of proximal development rather than to analyse the creation of 'an individual's' zone of proximal development" (Newman and Holzman, 1993, p. 81). Hedegaard attempted to develop "a zone of proximal development for the class as a whole, where each child acquires personal knowledge through the activities shared between the teacher and the children and among the children themselves" (Hedegaard, 1990, p. 361). In such a class, the "teaching should create zones of proximal development through involving children in new kinds of activity" (Hedegaard, 1990, p. 355). In my class we frequently encountered new kinds of activity through our mathematics course. We developed our collaborative classroom learning environment instead of following our traditional learning and teaching techniques as did Hedegaard who "intervened on existing classroom practices to reorganise the learning environment so that the children themselves could create a 'classwide' zone of proximal development" (Newman and Holzman, 1993, p. 84). When the pedagogic focus is on the whole class, as well as on groups within the class and the individual students, there is a clear emphasis on the social processes occurring within the learning environment. Such an emphasis is reflected in my constructivist perspective which I now find several other researchers sharing. "Common patterns of communication and interaction defined the nature and dimensions of a shared zone of proximal development for students in the mathematics classes" (Crawford, 1996, p. 53). As Crawford's project evolved, "the social characteristics of the setting - the shared zone of proximal development - for learning involved problem definition, argument, strategic decision making, risk taking and experimentation and self evaluation in a collaborative peer group" (Crawford, 1996, p. 56). Some researchers have hinted at the idea of describing Vygotsky's notion of the 'zone of proximal development' as a "construction zone" (Vare, 1993, April). In this stance we see the 'zone of proximal development' as a constantly changing entity that is influenced by a great number of factors. It is a 'fluid' or 'living' concept, much like the people to whom it is applied.

The 'construction zone' is considered more generally, as a field in which different meanings are negotiated and appropriated, rather than a distance between different levels of competence. This is an important corrective to the more hierarchical understanding of the ZPD (Bredo and McDermott, 1992, p. 33).

This interpretation is becoming a more common description of the 'zone of proximal development', namely that it is something within which, or through which, the student works, rather than the earlier definitions which implied that it was a static and measurable gap.
So this new approach to the 'zone of proximal development' allows one to view the concept as a dynamic structure embracing the changing developmental progress of the student as he or she collaborates with others. The basic message of the 'zone of proximal development' is the "interdependence of the process of child development and the socially provided resources for that development" (Valsiner, 1988, p. 145).

We should think of the zone of proximal development as characteristic not solely of the child or of the teaching but of the child engaged in collaborative activity within specific social environments. The focus is on the social system within which we hope children learn, with the understanding that this social system is mutually and actively created by teacher and students. This interdependence of adult and child is central to Vygotskian analysis of instruction (Moll, 1990, p. 11).

The important point here is that the 'zone' is created through social interaction and so each and every interaction re-creates the 'zone'. It is dynamic and developing along with the students.

Hence, the two key concepts for researchers utilising a Vygotskian perspective are:

First, the zone of proximal development; for collaboration to lead to development, interactions should be within the less competent partner's zone of proximal development.

Second, intersubjectivity; the process whereby participants in a task, who begin with different understandings of it, arrive at shared understanding in the course of communication (Tudge, 1992, p. 1365).

The first point helps teachers identify a 'zone' range to focus instruction on within their classroom. The second point emphasises the importance of discourse within the collaborative classroom learning environment. These points were priorities for the implementation of the environment for the class in my study and are "central to Tharpe and Gallimore's vision of education which is of a general re-definition of teaching as assistance of performance through the zone of proximal development" (Brown et al., 1996, p. 66; Tharp and Gallimore, 1988). Thus the 'zone of proximal development' is "an interactive system within which people work on a problem which at least one of them could not, alone, work on effectively (Newman, Griffin and Cole, 1989, p. 61; John-Steiner, 1993, p. 110). To develop a classwide 'zone of proximal development', with groups which contain students with overlapping (multiple) 'zones of proximal development', required the groups to be heterogeneous with a good mix of abilities. If all of the students had been able to complete the task, then none of them would have developed their abilities or their understandings nor would they have progressed within their 'zones of proximal development'. 
One further aspect of these dynamic 'zones' concerns the notion that they provide concepts with "a bi-directional pathway for development" (Lumpe and Staver, 1995, p. 71). This implies that students are able to move forward, towards higher level ('scientific') conceptual understandings, and backward, towards lower level ('spontaneous'/everyday) conceptual understandings, as they develop their understanding of concepts and work within their 'zones of proximal development'. A seemingly logical function for the 'zone of proximal development', linking with Vygotsky's notion of development for 'scientific' and 'spontaneous' concepts.

The 'zone of proximal development' was, for me, Vygotsky's principal concept in so far as it dominated within my thesis. However several of Vygotsky's other related ideas, such as 'scientific' and 'spontaneous' concepts, also had a role in defining my understanding of the theoretical constructs and practical applications which influenced my actions and beliefs during my research. The next section examines some of these other influences.

Interpretations of others

The principal ideas of Vygotsky's, among others, have been interpreted, adapted and applied in a myriad of ways by researchers the world over. Many of these researchers shed greater light on Vygotsky's ideas through their specialised interpretations of his writings while some highlight the worth of Vygotsky's ideas through their application of his principles in their research and related practical experimentation. This next section explores the interpretations of other researchers and adds further literature support for my interpretations and adaptations of a Vygotskian theoretical position.

There have been many and varied interpretations of Vygotsky's concept of the 'zone of proximal development', the latest of which I presented earlier in this chapter - my own. However, while I base my interpretation on Vygotsky's 1987 writings, my understanding of his meaning was influenced by my encounters with the interpretations of others which the following passage illustrates.

One of the appealing facets of Vygotsky's 'zone of proximal development' principle is how it considers the potential for a student's development compared to the limited more 'historical' nature of other developmental measures. "Such measures are undoubtedly important but they are incomplete" (Vasta, Haith and Miller, 1992, p. 356-357). Interpretations of Vygotsky's 'zone of proximal development' principle, that are widely supported by researchers and which appeal to classroom teachers,
include the one applied by Campione, Brown, Ferrara and Bryant. "Vygotsky's ideas are normally used to explain differences between individuals. Brown and her colleagues have extended Vygotsky's notions to explain group data" (Washbourne, 1984, p. 59). "Although Vygotsky focused on child-adult relationships, his theory can also be applied to peer interaction, especially those involving heterogeneously mixed groups with respect to prior ability" (Lumpe and Staver, 1995, p. 92). "When interacting with adults or peers children can operate far beyond their actual level of development. Thus instruction can contribute to the creation of a new 'zone' of proximal development" (Pontecorvo, 1990, p. 11).

When a teacher closes the gap between task requirements and what the learner can accomplish on his or her own, this process of collaborative work between teacher and learner often advances the learner's skills as well as accomplishing the task at hand. The reason for this effect lies in what Vygotsky conceptualised as the 'zone of proximal development' (Greenfield, 1984, p. 118).

Vygotsky saw the 'zone of proximal development' as being created by learning. Learning awakens a variety of internal developmental processes that are able to operate only when the child is interacting with people in his or her environment and in cooperation with his or her peers. These processes become part of the child's independent developmental achievement once they are internalised. "The zone of proximal development relates education and development in a theoretically convincing way" (Oerter, 1992, p. 198). It further relates education and development in a particularly effective way when utilised within a peer interactive learning environment as was this case in this study.

"Vygotsky's conception of the zone of proximal development stresses the child's ability to profit from interaction with more competent others" (Damon and Phelps, 1989; Vygotsky, 1978). Several studies have shown that "although working with a partner who is slightly more skilled may be most effective, working with a partner equal in skill, or even one less advanced, may still yield progress" (Forman and Kraker, 1985; Glachan and Light, 1982; Light and Glachan, 1985; Rubstov, 1981; Rubstov and Guzman, 1984-1985; Rogoff, 1990, p. 173). These authors all hint at a wider interpretation of Vygotsky's 'zone of proximal development' principle than they or others have applied. Pontecorvo (1990) and Hedegaard (1990) in particular address this breadth with Hedegaard's 'classwide' 'zone of proximal development' coming closest to a practical school based application of Vygotsky's 'zone of proximal development' principle. The key to this more practical application of Vygotsky's concept is in considering the 'zone of proximal development' as a dynamic concept which is in a constant state of flux, a 'floating zone'. In this study,
which had the students working in groups, these dynamic interacting 'zones' were represented visually, with the ideal in a group work context looking something like this:

![Figure 1](image1)

'Zones' - ideal

Each student's 'zone' (S1 - most able to S4 - least able) is 'covered' by a more able peer and in the case of the most able student of the group (S1), by the teacher (T), the curriculum, the text, the class 'collective' and so on.

Other possibilities look something like this:

![Figure 2](image2)

'Zones' - teacher gap

Figure 2 highlights how the teacher, the curriculum, the task, the text or whatever are set beyond the students' proximal 'zones' and thus it is unlikely that learning will occur.

![Figure 3](image3)

'Zones' - student gap

Figure 3 highlights how, in this case, the less able students, S3 and S4, are without any link to the learning occurring in the environment or class and thus, in such a setting, they are not provided with a learning opportunity.
A similar representation of all the students in a class would also indicate Hedegaard's (1990) concept of a 'classwide' 'zone of proximal development' as Figure 4 overleaf illustrates. Most students (S19 to S17) would be able to grasp the 'taken-as-shared' or classwide concepts although a few (S21 and possibly S20) would not yet have reached this stage while others (S1) would be ahead of the class in their understanding of the concepts being addressed. Thus we see the practical nature of Vygotsky's ideas, especially the 'zone of proximal development' principle. That these ideas are best utilised within an interactive classroom environment receives wide support within the literature as the passage following Figure 4 overleaf explains.

Vygotsky's theory of instruction involved the interaction of a student with a more capable other and follows the developmental line of interpersonal understanding leading to intrapersonal understanding. Contrary to Confrey's views (Confrey, 1995, p. 204-207), I believe this calls for creativity and dissent for these are expressions of a student who is in the process of constructing meaning of what they have experienced during the interaction. I also perceive the aspect of the student teaching the adult or more capable other (peer) as fully functional and potentially enhanced when those 'others' are peers working together in groups. I believe the Vygotskian instructional model is enhanced and enriched through the use of collaborative peer interactive groups.

A Vygotskian perspective supports the importance of such alternative teaching strategies as using collaborative groups, providing opportunities for significant peer interactions, and presenting and
posing problems beyond students' zone of comfort so that they can maximise learning and bridge their zones of proximal development (Taylor, 1993, p. 3).

"A visitor to any primary school will see children teaching other children. Some of the peer teaching that occurs in school is child-initiated, as children spontaneously help each other and some peer teaching occurs as a deliberate part of the school curriculum" (Vasta et al., 1992, p. 550). This study took advantage of, built on and extended this primary school ethic by encouraging the same peer interaction behaviours in this, the students' first high school year.

Vygotsky considered "that the most effective form of instruction" involved interaction and collaboration with others (El'konin, 1963). "Vygotsky argued that the social context of learning may be used to extend what he called the 'zone of proximal development' such that learners can be more effective than if they were learning alone" (Linn and Burbules, 1993, p. 97). Newman added "the role of the social context is to scaffold the learner which extends the 'zone of proximal development' for students and enhances knowledge construction" (1990). In adopting or following Vygotsky's general approach to child development and learning I undertook to follow his lead in terms of researching the course of learning and teaching in classrooms as advocated by Simon and Simon (1963, p. 11). I believed it was possible to argue that modern curricula, and in particular the curriculum I followed at my school while implementing this study, tended to be made up of content that is a little ahead (sometimes way ahead) of the students' development. Thus it was that my study encouraged interaction among the students in our developing peer collaborative mathematics classroom within the 'normal' high school learning environment.

That Vygotsky's theories offer a basis for flexible wide ranging interpretation is clearly represented by the broad spectrum of views presented above. "Undoubtedly part of the reason for the current (1990s) popularity of Vygotsky's work lies in its fit with contemporary ideas about the importance of social factors and contexts in explaining children's behaviour" (Vasta et al., 1992, p. 550). We must continue to extend the applications of Vygotsky's work into educational institutions and practical contemporary situations to further develop his theories in the modern context.

"Learners develop conceptual knowledge by means of a dynamic, Vygotskian-like appropriation (internalisation) of socially embedded conversational forms and associated practical activities" (Brown, Collins, and Duguid, 1989; Palincsar and Brown, 1984; Wertsch, 1991; Martin and Sugerman, 1993, p. 21). I, along with these authors, see Vygotskian theory as a way forward for a research community
which has lost its way. In a similar scenario Ratner (1991) perceives Vygotsky's theoretical development of psychological concepts as the way forward for a science (psychology) which he believes has stagnated in recent times. Vygotsky was a man before his time and is, I believe, a man whose time has now come. Hence I have embraced his theoretical constructs and implemented them into my practice. Now I shall briefly review why I have done so.

Summary - Vygotsky

The system of education which I personally experienced as a student at school, as a trainee teacher and within which I work as a teacher, is profoundly influenced by and built upon a Piagetian pedagogic perspective.

In this study my interests focused specifically on the development of a collaborative peer interactive learning environment. There is "not just one mechanism underlying the facilitating effect of peer interaction". Indeed, "Vygotskian and Piagetian approaches should be considered jointly for better comprehension of the processes at play" (Blaye, 1990, p. 55). So in adopting a Vygotskian perspective I need not abandon my Piagetian ways for these still influence my pedagogic approach and acknowledging this symbiosis enhanced this research.

The preceding section established links between a Vygotskian perspective and contemporary research in mathematics education.

Vygotsky's methodology, the integralness and historicism of his approach, is the cornerstone of his work. Even today, it provides a model that has not been surpassed. It is precisely the integralness and historicism of his approach that guarantee the relevance and the constructiveness of his ideas (Luria - afterword, in Vygotsky, 1987, p. 372).

"In the 48 years since Vygotsky's death, many of his followers have put his plans into practice and convincingly demonstrated the tremendous implications that his ideas have for the rational reconstruction of pedagogical science and practice" (Luria - afterword, in Vygotsky, 1987, p. 367).

The importance of Vygotsky's work as a cornerstone in this study led me to a personal examination of translations of Vygotsky's own writings. My interpretations of Vygotsky's concepts form the methodological and theoretical perspectives through which I viewed my research. Of particular importance in this study were Vygotsky's notions of the 'zone of proximal development' and of 'scientific' and 'everyday' (or 'spontaneous') concepts which were highlighted earlier.
From my perspective, Vygotsky achieved credibility because his theories still seem relevant to our modern situation, and because his approach gives a fresh perspective from which to view the pedagogic process. Vygotsky believed that for the first time in such research, his work and that of his colleagues had satisfactorily resolved two important issues on the experimental plane. The first "was to provide an experimental assessment of our working hypothesis concerning the unique developmental path of the scientific concept" and the second "was to resolve the more general problem of the relationship between instruction and development" (Vygotsky, 1987, p. 239). From Vygotsky's perspective, the most important indices of the plausibility and fruitfulness of his research was "fact that the experimental research and theoretical hypothesis, though developed simultaneously, led not only to consonant but to fully unified findings" (Vygotsky, 1987, p. 240).

My support of and interest in Vygotskian approaches to learning and teaching are shared by my contemporaries in modern Russia. They see the teacher as having "an equal role to play in the development of the students' subject knowledge and the students' social abilities" (Prucha, 1990). This perspective places great significance on the role of integrating the approaches of teachers, students, parents and the school community at large in developing activity which leads to learning. Allowing time for the students to reflect, communicate and work collaboratively is also an important characteristic of the learning environment constructed from this perspective. The use of discourse within the classroom further enhances understanding for the students in such learning environments. These perspectives helped form my background beliefs and hence played a significant role in my study.

Just as discourse enhances student understanding in class, the discourse of the research community enhances my understanding of the theories influencing my study. Thus an important step in gaining a broader perspective of how my views were situated in the greater educational research community was achieved through an examination of the interpretations that others give to Vygotsky's writings. In carrying out such an investigation in the previous section, I have attempted to unify the principal perspectives behind this research, namely those of mathematics education and Vygotskian pedagogic theory.

In the next section I extend this unification to include aspects of a constructivist perspective. I also examine the socio-cultural influences evident in the theoretical approach I adopted for the implementation of a collaborative peer interactive learning environment into my research setting - my classroom.
CONSTRUCTIVISM

Introduction

While Vygotskian perspectives underpin the principal theoretical constructs for my study, constructivism - "a theoretical referent concerned with knowledge" (Bettencourt, 1993, p. 39) - also influenced my research. E. von Glaserfeld, a premier author of constructivist doctrine, refers to constructivism as "a theory of knowing rather than a theory of knowledge" (von Glaserfeld, 1993, p. 24). In the following section I describe my internalised concepts of constructivist theory to explain how I have associated these with my Vygotskian perspectives.

Linking Vygotsky to Constructivism

The myriad different perspectives of constructivism have distinct premises that set them apart from one another. Vygotsky's "socio-cultural theories of learning focus on the influence of participation in social and cultural practices in mathematical learning" (Nesher, Owens, Balacheff, de Corte, Steffe and Steiner, 1994, p. 121). Thus the form of constructivism I found most compatible with my Vygotskian perspectives is that of socio-cultural constructivism or social constructivism which "is inspired in large measure by the work of Vygotsky and that of Activity Theorists such as Davydov, Leont'ev, and Galperin" (Nunes, 1992; Cobb, 1994, p. 13). Social constructivism reflects the influence of social interactions whereas radical constructivism and similar forms focus on the individual, a very Piagetian stance. Some would view my constructivist position as 'trivial' but this is because I am more Vygotskian and a socio-culturalist than constructivist. I am also a teacher and it seems that "an independence exists between discussions about radical constructivism and teaching" (Lerman, 1996a, p. 147). This independence is manifest among constructivists who claim that the constructivist paradigm is a way of knowing and not specifically a way of educating, or especially not a way of teaching, and particularly not a way of teaching mathematics. Having sufficiently distanced themselves from the chalk face, we can see why such independence is claimed to exist. But mediation, according to Vygotsky, is the link between knowledge and learning. Meditation in the form of materials, used to model ideas, and tools, such as language and so on, used to express those ideas. Both the materials and the tools allow the learner to share those ideas with 'others' - peers, teachers, family and society. Thus the ideas, and their associated meanings, are shared intersubjectively.
A central thesis of social constructivism is that the unique subjective meanings and theories constructed by individuals are developed to 'fit' the social and physical worlds. The main agency for this is social interaction. This results in the negotiation of meanings, the correction of verbal behaviour and the changing of underlying meanings to improve 'fit'. Briefly put, this is the conjectured process by means of which the partial inner representation of public knowledge is achieved (Ernest, 1991, p. 105).

Vygotsky's social theory of mind offers a strong parallel with social constructivism and this union was most important to my study. Our classroom environment was designed with these concepts in mind, ensuring that by working in groups the students developed their knowledge via the interpsychological which then progressed to the intrapsychological. "Vygotsky's point is that development is not the process of the hidden becoming public, but on the contrary, of the public and intersubjective becoming private" (Williams, 1989, June, p. 113). Confrey suggests that a Vygotskian perspective better facilitates the adoption of a constructivist approach. "A Vygotskian perspective can make the actors in teaching and learning processes become aware of the existence of patterns of interaction which are more compatible with constructivist goals for instruction and can be integrated into the classroom" (Confrey, 1995, p. 214). Vygotsky wrote:

"The personal activity of the student must be placed at the base of the educative process, and all the teacher's art must come down to directing and regulating this activity" (Vygotsky, 1991, p. 82; Davydov, 1995, p. 17). While most teachers would consider this a fairly obvious or commonsense statement, it is particularly constructivist and thus provided another link in my interpretation of the Vygotskian and constructivist approaches. It was from Vygotsky's emphasis that the approach for my study was developed to highlight social interaction and to encourage a broader role for the students in influencing each other's 'zones', a task they could do better as groups than the teacher could do in the more traditional 'teacher-student' role.

In 1982 "Novak raised the Vygotskian point that environment can influence children's conceptions" (Cobern, 1993, p. 54). In adopting a Vygotskian perspective I was endeavouring to develop an environment which better matched the constructivist perception of how a classroom should function. The unique nature of my study draws parallels with implementations and ideas such as "cognitive apprenticeship" (Brown et al., 1989; Rogoff, 1990) and "the construction zone" (Newman et al., 1989), concepts which derive from ideas about Vygotsky's 'zone of
proximal development'. In adopting constructivism I needed to be aware of how this viewpoint functioned in the classroom. "In constructivism, a zone of potential development of a specific mathematical concept is determined by the modifications of the concept the student might make in, or as a result of, interactive communication in a mathematical learning environment" (Steffe, 1991, p. 193). "The constructivist model emphasises the importance of a two-dimensional flow of information between the teachers and their students" (Bodner, 1986, p. 877).

"For Vygotsky, collaboration in the zone of proximal development relies on support based on children's starting points to aid children in reaching greater understanding" (Rogoff, 1990, p. 202). This perspective tied in strongly with the constructivist notion of building new concepts upon what the learner already knows.

The process of developing higher order thinking relies on the role of a social community in establishing norms of behaviour, providing opportunity for practice, and occasions for learning particular skills. The process of learning is aided when there are many opportunities to observe others engaging in such thinking activities. These processes require sustained long term cultivation and do not emerge from short term quick-fix interventions (Resnick, 1987, p. 433-434).

There were certainly many opportunities in my study within the context of almost every lesson, for the students to have their thinking valued, be able to ask any type of question, and express judgments or criticisms. I always accepted invalid or incorrect solutions or comments from the students in order to encourage their participation.

We must build into the activities that we offer learners the opportunity to interpret, to negotiate meaning, to be challenged and thereby to construct some new understanding of their own which might, or might not, be matched by the understandings of other learners in the same class (Malone and Taylor, 1992, p. 2).

Most of the work in which the students in my study engaged fell into this sequence of activities for knowledge construction. Matching the understandings of others is the quest for intersubjectivity which is enhanced through discussion in the classroom.

In a socio-culturally aware constructivist learning environment, the foci are prior knowledge, reflection, collaboration, negotiation and seeking consensus. Such a classroom utilises the students' prior knowledge to encourage their active participation in the construction of meanings related to new concepts as they encounter them. This will involve the students in reflecting on what they know and
collaboratively negotiating a consensus regarding the concepts they are examining. This next section examines some of these foci.

**Prior Knowledge**

Awareness and utilisation of the students' prior knowledge is an essential cornerstone of the constructivist teacher's approach to learning and teaching. In its guide to good practice for mathematics teachers, the Australian National Statement for Mathematics points out that the "learning experiences which teachers provide should build on the strengths with which students come to the classroom and broaden their horizons and the range of contexts in which they can function" (AEC, 1990, p. 9). The importance of prior knowledge is highlighted by research findings such as those which found that "prior knowledge had a more significant relationship with mathematics achievement than did intelligence" (Weinert, Helmke and Schneider, 1990, p. 467), and others which found that "building on and stimulating recall of prior experiences was essential for further development of concepts" (Clarke and Kessel, 1995, July). The social constructivist teacher must also be aware of the Vygotskian notion that "prior knowledge need not have been developed in class, it may have arisen in and out of class activity" (Bishop, 1995, July). The teacher is never alone in the teaching of the students: they are also influenced by peers, families, society and so on.

Critical to our understanding of how it is that constructivism leads anywhere, as far as the development of students' knowledge is concerned, is the realisation that the teacher has a role to play and that the students do not do it all on their own as some interpretations of radical constructivism would imply. "The teacher facilitates the students' mathematical development by subtly highlighting selected aspects of their mathematical contributions" (Yackel et al., 1990, p. 35). In a constructivist environment the students work together and debate or discuss their ideas and solutions as they attempt mathematical tasks. The situations which the students examine "provide opportunities for the development of their problem-solving skills" (Zevenbergen, 1995, p. 78) as was evident in the classroom in my study. The beauty of this approach is that it takes into account students' individual differences in prior knowledge and so gives support to the constructivist notion of building on each individual's background knowledge base.
Constructing Meaning

The students must construct meanings for themselves, each other and the collectives they are working in as they encounter new concepts. The constructivist teacher has the crucial role of negotiating many differing views into one, preferably globally acceptable view of 'taken-as-shared' mathematics. "The students will all possess their own understandings which will be inherently different from one another and from the teacher. The teacher will have to account for this variation and be able to act on this difference in understanding" (Pirie and Kieren, 1992, p. 508). The teacher must also realise that once this communal knowledge base is established it is only temporary and that outside the classroom community it is subject to decay or to improvement. Hence the need for reinforcement.

Constructing meaning, individually or collectively, within a mathematics classroom requires a considerable degree of discourse between all the participants and most importantly between the students. The value of group work and collaborative activity is paramount in the constructivist classroom.

Both the student and teacher must learn to talk and listen. To be effective, the student's construction of mathematics must allow the student to carry on a mathematical discussion, that is, to participate as a member in a mathematically literate community in the classroom (Richards, 1991, p. 46).

Just listening to the students is a good start. Building on what the students said, right or wrong, was standard practice in the class in my study. Thus we had the students constructing meaning, based where possible on their prior knowledge, and doing this by engaging in collaborative discourse. "The constructivist classroom emphasises establishing a mathematical community, engaging in lots of teacher-student student-student interaction, encouraging mathematical thinking and promoting the kinds of questions and comments that help community members to challenge and defend their own constructions" (Davis et al., 1990, p. 3). Pirie and Kierens' view is that "to observe the kind of understanding exhibited by a student, a teacher must prompt students to justify what they say or do and thus reveal their thinking and logic" (1992, p. 509). Lochhead too suggests that "in general, the teacher should spend more time listening to students than the students spend listening to the teacher" (1991, p. 78). This was always the policy in the classroom of my study in that students knew that they could be called on to justify, explain or elaborate on their results. Our constructivist classroom shifted "the focus from teacher delivery of 'knowns' to learner investigation of 'unknowns' " (Malone and Taylor, 1992, p. 2).
The unknowns belong to the learner (the teacher probably knows). This is now a widely accepted viewpoint and is modelled by a constructivist approach.

**Adopting Constructivism**

I adopted a constructivist approach for my study to determine if it was or was not a viable approach for use in the mathematics classroom. In doing so, I modified my existing teaching methods to better reflect what I perceived as following a constructivist model. However, just as constructivism does not form a complete pedagogical foundation, it cannot be adopted for 100% of the time in the classroom. "A constructivist view of learning does not translate directly into any particular model of teaching" (Simon, 1994, p. 75) however it is clear that "any instructional act that facilitates students' construction of powerful mathematical ideas is a useful one" (Simon, 1994, p. 75). As far back as 1912, visionary educators such as Maria Montessori were urging teachers to "plan their instruction around the natural and spontaneous behaviour of children; to let the child's natural tendencies toward learning lead the way" (Galloway, 1976, p. 255). "'At best, the teacher can orient the students' constructing in a fruitful direction, they can never force it' - Maria Montessori (1912)" (von Glasersfeld, 1993, p. 34).

Working within a constructivist paradigm does not mean any particular style of teaching. Rather it implies adopting a style or process that facilitates the students in their construction of knowledge. "As the students are learning mathematics, the teacher is learning about mathematics, learning, teaching, and about the mathematical thinking of their students" (Simon, 1995, p. 141). In this environment the teacher and the students have much to give and much to acquire. "We must value and respect what the student knows - not just because of constructivism but because doing so enhances the student's self esteem / worth" (Bickmore-Brand, 1993). Being aware of the students' prior knowledge and experiences and utilising these wherever possible is a principal focus of the constructivist classroom environment. "Learning is built on existing knowledge" (CC, 1997, p. 199). "Learning results can be improved when students' preconceptions are activated both before and after the presentation of the new material" (Ali, 1991, p. 79-80). This was a common occurrence in the lessons in my study. "You need to teach the students how to use their preconceptions in the learning process" (Ali, 1991, p. 81). How does a teacher do this? Make the students aware of the worth of their preconceptions by having the teacher value their contributions of such background information. In my study the
class and the groups were often challenged by the teacher about their preconceptions and it became common place for the students to challenge each other and even themselves from time to time.

Constructivism becomes manifested in classrooms where teachers recognise and value the role of dialogue in the construction of meaning. Students are given opportunities to discuss with their peers and teacher. Further to this dialogue, students are encouraged to reflect on activities and experiences. Dialogue and communication are integral components of constructivism whereby, through engaging in collaborative dialogue, students are challenged to see other students' perspectives (Zevenbergen, 1995, p. 77).

Dialogue or discussion is evidence of a constructivist approach - evidence which was clearly observed in my study - especially collaborative dialogue. The students were always challenged to see other students' perspectives in my class. Collaboration is a key process in the social constructivist approach to developing a functional learning environment. "How can we induce the engagement that is essential if students are to perform powerful constructions? The use of small groups in cooperative learning is becoming a popular strategy for increasing the amount of time students spend working together" (Noddings, 1990, p. 17). By working collaboratively in groups, the students' interpretations are likely to be more of that of a community (their group) than those of individuals. Collaboration probes each individual's commonalities through an examination of their prior experiences. It then builds upon new experiences that involve the exploration and construction of meanings acceptable to the student, and through social discourse, acceptable to the collective, be it the group, class, or the broader mathematics community.

Until recently, "most proponents of constructivism have focused attention on the elementary grades, to the neglect of secondary and post-secondary instruction" (Confrey, 1994, p. 6). This is because the constructivist approach is so much more at odds with common secondary and post-secondary practices. Elementary or primary schooling is oriented towards the individuals or students as people, and is thus more accepting of the student-centred approach, which constructivism extols. Secondary and post-secondary practices are much more strongly linked to a subject and consequently are far less student-centred than primary practices. My study extends the 'trend' of constructivism research into the secondary school arena through the adoption of a collaborative peer interactive learning environment that was informed by perspectives utilising Vygotskian pedagogy and the constructivist paradigm. The merger of these theoretical constructs not only made them viable and functional
within daily practice in the classroom, but also pointed me further along the constructivist 'paradigmatic trail' towards a more socio-cultural position. The following section examines this facet of the theoretical underpinnings for this study.

Socio-cultural facets

The Vygotskian influences on my study extended to my interpretations of constructivism. My experiences as a classroom teacher, working with upwards of 120 high school students every day, also 'filtered' my interpretations of constructivist teaching and constructivist learning environments. The outcome was my alignment with a more social and cultural interpretation. "Knowing is a socially and culturally situated constructive process" (Cobb, Yackel and Wood, 1992, p. 8). "The range of interpretations of the role that the social context might play in teaching and learning mathematics has resulted in a wide range of approaches" (Lerman, 1996b, p. 1). This is the 'next' stage in the evolution of the constructivist paradigm: from radical to social and on to socio-cultural. "Social constructivists seek to modify the isolation and solipsism of the radical view by incorporating a stronger role for social interaction" (Lerman, 1996b, p. 2-3).

Social constructivism acknowledges that the learning and teaching process is social which in turn reflects the reality of schooling today. Socio-culturalism enhances this perspective by acknowledging "the characterisation of learning as a process of acculturation which involves fulfilling certain obligations to the school as a social institution, and to a wider society" (Cobb, 1994, p. 14). This is the closest form of 'constructivism' to that which I utilised in my study.

The socio-cultural approach incorporates essential social elements to underpin the classroom learning environment and the related developing mathematical community. "The mathematics classroom is a mathematical community which greatly influences the students' opportunities for learning. The classroom community is engaged in constituting a shared mathematics, taken-as-shared from the perspective of the observer" (Simon, 1994, p. 74). Once or twice in the class in my study we even invented our own 'shared' mathematics. The social constructivist perspective "sees mathematics as both cognitive activity constrained by social and cultural processes and socio-cultural phenomenon that is constituted by a community of actively cognising individuals" (Wood, Cobb and Yackel, 1995, p. 402). Thus, the social aspects are now being grounded within the culture that regulates such social activity, and constructivism evolves into socio-culturalism.
Cobb contends that "the two perspectives, constructivism and socio-culturalism, can be viewed as complementary" and that "the central issue is to explore ways of coordinating constructivist and socio-cultural perspectives in mathematics education" (Cobb, 1994, p13). This study represents one such exploration. In suggesting that mathematics education researchers need to examine ways of coordinating the two perspectives of constructivism and socio-culturalism, Cobb "acknowledges that teachers have got something interesting to say when they argue that the tension in teaching between individual construction and acculturation cannot be resolved once and for all" (Cobb, 1994, p. 19). This study attempted to document and reflect on its trial in coordinating these two perspectives. Another such trial by researchers Cobb, Boufi, McClain and Whitenack has developed a 'middle ground' position which is described as the emergent viewpoint. This perspective "believes in an indirect link" between individual and collective processes where "participation in collective processes constitutes the conditions" for learning (Cobb, Boufi, McClain and Whitenack, 1995, July). This contrasts with a purely socio-cultural perspective which sees such a link as direct. I see the reality of the situation as being a mix of these conditions where the community feeds off the individual and the individual feeds off the community thus individual and collective processes are mutually mediating. The teacher's role, from a socio-cultural perspective, involves the "teacher mediating between personal and cultural meanings" (Cobb et al., 1995, July). The emergent perspective sees the teacher as monitoring the "emergence of individual and collective systems", helping students to "build up towards a cultural community" (Cobb et al., 1995, July). These perspectives are not so different. My view was to build up the individual and collective systems into a classroom community culture which mediated between personal and collective meanings. The emergent viewpoint may be the next label under which constructivism advances but, as stated earlier, the closest theoretical position to that which I utilised in this study is socio-culturalism.

Summary - Constructivism

One must acknowledge that constructivism is an overarching paradigm whose precepts embrace a wide range of observations about learning. The applications of constructivism are diverse and mathematics education research in particular is presently strongly influenced by the constructivist perspective. Constructivism brings ideas out of the classroom and into the mainstream of educational research and it has emerged from its initial position to include social aspects of learning. The constructivist classroom, as modelled by this study, involves the teacher in reflecting questions back to the student and directing the student's responses toward
acknowledgment that they had an acceptable solution and that it is worthy of recognition. The teacher's answer deserves no more recognition than does those of any student. The "real satisfaction is the 'rightness' within" (von Glasersfeld, 1988, p. 335).

In such a classroom the teacher has a dynamic role to play in the evolution of students' concepts in their 'everyday' form (if such exist in the context being studied) and in their 'scientific' form. This is achieved through the use of curriculum materials, designed as cultural tools, and the utilisation of an effective learning environment such as that which was developed in this study. In such an environment the students make sense of things for themselves and interact with their peers to affirm their ideas. The teacher monitors this interaction and plans any required intervention or determines where to progress next in terms of unfolding the students' understanding of the culture of the greater mathematics community. In the classroom researched in this study I encouraged each student's construction of knowledge, I accepted the variety of ways students did things, I did not insist they conform to my or any other official way, and I encouraged the students to help each other (construct the same or other knowledge) by having them work together in a peer interactive environment. All of these aspects reinforce the constructivist perspectives which were guiding our learning and teaching processes.

My adaptations of constructivism from its 'pure' form to its social form to its socio-cultural form followed my need to work within a Vygotskian framework and my belief in the role of collaboration within the classroom. My needs and beliefs shed light on the needs described by Lerman who argues for a different kind of individualism within the constructivist framework.

In a sense I am arguing for a different kind of individualism; since any pupil will be situated in many contexts, depending on his/her socio-cultural experiences (including unconscious ones), the teacher may not always be able to predict what will be called up by the activities he/she offers. Consequently, we need to find ways of enabling pupils to find, create and negotiate their meanings within the classroom, whilst recognising that the 'classroom mathematics setting' is another, perhaps the main, discourse (Lerman, 1996a, p. 144).

That students are situated in many contexts is one reality which, in my study, led me to use seven categories of prior experiences to determine my initial student groupings (detailed in Chapter 3). Another reality was using materials and activities in which the students were not immediately able to predict the outcomes. This
makes the mathematics environment richer and more enjoyable for the students because they know their experiences can have some bearing on those outcomes and with that much variety of input, the subject takes on more significance for the learners. In the learning of mathematics (in the context of coming to terms with the taken-as-shared mathematics culture) the students’ classroom environment (of which the physical aspect is only part and a minor one at that) is the main part of their socio-cultural experience within which that learning occurs. It is the role of the teacher in such an environment to determine ways of enabling the students to find, create and negotiate their meanings within the classroom. The teacher must accept the students’ ideas and work with them and build on them or help the class modify them as appropriate in order for all students to develop the concepts. Such an environment has the potential to take advantage of the socio-cultural forces the students bring into the classroom and which subsequently make up the dominant socio-cultural learning environment of the mathematics classroom within which they will work. So we have all of the social input that the teacher and each student brings to bear on the classroom. Together the teacher and the students develop the classroom social culture. Within this environment they all assist each other to appropriate the culture of a community of mathematicians which, for the students (and often for the teacher), then becomes a further social practice.

Final reflections on the Literature

The preceding literature review has illustrated how my study came to be informed by the multiple perspectives of Vygotskian pedagogy, collaborative learning and related research in mathematics education, and forms of constructivism which have emerged to reflect a socio-cultural stance. The next chapter examines the literature supporting the methodology adopted within this study including facets of ethnography, action research and learning environment research. The following reflections conclude this chapter and highlight some of the more interesting facets of the discussion to date.

I adopted a Vygotskian perspective because, from reading his works, I became convinced that his ideas about peer interaction were a correct description of the pedagogical process as distinct from descriptions which promoted confrontationalism, with which I personally felt uncomfortable when teaching. That students often came to me with a poor attitude to my subject, mathematics, concerned me and I did not wish to make things worse by being confrontational in order to get the ideas across. I was aware of teachers who thrived on such an approach, as it was in their nature to be confrontational and aggressive, but I believed their successes were limited and did not lead to any long term learning benefits, nor understanding nor, for that matter, to
the creation of a love of learning. I believed that one of my duties as a teacher was to try to develop in students a love of learning. This need not focus specifically on mathematics but should embrace any quest for knowledge. Hence I found my Vygotskian perspectives merging with constructivism, a way of knowing, a path to knowledge, a philosophy of learning, which had emerged from the research literature on mathematics education in the early 1980s.

While constructivism does not 'tell us what to do', we know that constructive learning must occur independently of instruction. Vygotsky said that good instruction must lead development and so, putting these together, we get good instruction leading development and leading to constructive learning. Thus I elected to develop a classroom learning environment which reflected these multiple facets. I was, and still am, clear in my mind as to the theoretical underpinnings of such an environment and I attempted to develop the same awareness in my students by leading them in the implementation of our collaborative peer interactive classroom learning environment. However, schools are a complex social milieu and I found that other teachers and other environments also influence the students every day, and so I had to confirm our mathematics class environment nearly every lesson. The benefit of this was apparent, as regular confirmation of our developing pedagogic model helped me focus on the theoretical background and the day to day methodology and helped the students focus on their learning and collaborative processes. As the teacher, I was frequently coming out of a non constructivist environment from a prior lesson, and so such reminders were timely.

Our roles emerge

Thus my role began to emerge. A facilitator, a teacher, a researcher. An investigator who was keen to examine the viability of several theoretical constructs in the real world of his mathematics classroom. To achieve this I had to focus on the learning teaching environment. "The role for the teacher is to create an environment in which students feel free to (a) share their beliefs and opinions, (b) ask what, how and why questions, (c) take risks, (d) hypothesise, and (e) make mistakes" (Vacca, 1993, p. 225). I felt I was successful in fulfilling this role for, as can be seen in the observations in Chapter 4, the students did all of these things in the environment created by the intervention in my study. Similarly the role of the students also emerged. To be able to do all of these things, discourse must flow freely and yet "researchers and classroom teachers such as Pirie and Schwarzenberger (1988) and Smith (1987) have suggested that mathematical discussions rarely occur even though calls for them are widespread" (Lo and Wheatley, 1994, p. 145). In my study there
was ample evidence of mathematical discussions, for our operating environment was very conducive to such discourse.

Extensive interactive communication seems to be a common feature of quality mathematics learning environments. The meanings teachers and students have constructed from a wide variety of schooling experiences and external societal pressures inevitably contribute to the nature of classroom interaction (Mousley et al., 1992, p. 138-139).

My secondary role was to focus this interaction on the positive development of our classroom learning environment.

The teacher's attempts to understand the individual student's approach generates a climate of positive social interaction. Genuine interest in how they think shows the students that they are being taken seriously and this, in turn, enhances their courage to try and openly discuss new concepts (von Glaserfeld, 1991, p. xvii).

The key here is trust. As their teacher I believed in what we are trying to achieve and I believed in the students' role in all of this. Doing so led to acceptance of the situation by the students and hopefully aided the implementation.

Our journey proceeds

With these 'goals' in mind and our roles defined by the theoretical underpinnings for this study we began to see many occurrences of how things happened in our collaborative peer interactive classroom learning environment. Our 'cause was just', for "the research on peer learning clearly demonstrates that children can assist others to learn and, in doing so, lead to consolidation and understanding of knowledge, skills, and teaching-learning processes" (Gillies and Ashman, 1995, p. 85). While the research supported our use of a collaborative learning environment we were wary of potential pitfalls which we might encounter along the way.

Even teachers who try to develop learning environments that feature rich interactive dialogue are prone to lead rather than to guide (Voigt, 1985). In one sense this is inevitable because, as Cobb (1990, February) has emphasised, the claim that students can discover mathematics on their own is an absurdity (Mousley et al., 1992, p. 111).

Indeed, as our later observations show, I did drift back into 'old' ways from time to time. What was important for us all to acknowledge was that there was a sense of inevitability about some aspects of our 'traditional' ways. However, our chosen learning teaching environment, a collaborative peer interactive classroom, offered
many benefits and so it remained our focus throughout the study. Indeed, it would be true to say that "there was general agreement between students and teacher regarding the purpose and benefits of collaborative small-group instruction in mathematics" (Mulryan, 1994, p. 289). Some of the benefits from working in small groups include the following ways of making the best use of the learning time in the classroom:

- students have more incidental and planned opportunities to use language (reading, writing, listening, talking) as an instrument of learning.
- students can learn from each other and they can teach each other.
- students can learn to recognise that their own experience and thoughts are of value when they are learning new information (EDWA, 1984, p. 3).

Thus we were drawn to the conclusion that our collaborative peer interactive classroom learning environment was one in which:

students undertake a task or set of tasks collaboratively, giving and receiving help, ideas, opinions, and information that can aid each member of the group in completing the task. It also provides students with opportunities to engage in higher order thinking and problem solving in a way that is not often possible in regular mathematics lessons (Mulryan, 1994, p. 289).

Through this intervention, the students came to acquire the desired behaviours, norms and skills which facilitated the successful operation of our collaborative classroom learning environment.

The preceding section has highlighted many key ideas from within the literature and from within the process that is my study. Much of what can be expected to be seen, and which the literature endorses, is seen in our observations, but there is also much to be seen that is not expected. If someone walked into the classroom during the study he or she would have noticed that order and harmony were not the norms. We frequently had loud, 'messy' discussions and yet this behaviour yielded the following very vital personal observation taken during the study. This raw data observation extract is presented in Helvetica font to distinguish it from the thesis report.

When a discussion seems to me to be out of control, with many people talking at once, the students in fact are taking it all in and indeed resolve from the melee those comments deemed to be the most relevant. At times someone shouts, 'hey, everybody, let so-and-so speak', (they are already but not everyone is listening), 'she knows what to do' or whatever. So during 'multi-speak' most of the students are either listening and analysing the output of several speakers or speaking themselves while simultaneously listening to others speak.
Perhaps this is the strongest evidence yet for an active role for 'inner voices' - speaking thoughts existing alongside listening thoughts - which for this age child, early adolescent, sees 'inner thoughts' becoming more conscious or controlled as the student becomes able to process thought for speech while at the same time processing thought brought about by listening. This accounts for how it is that we often lose the thread of what we are saying because we are off thinking about what to say or do next before we finish our current speech statement.

That is, 'er ... ... what was I saying?'

Indeed, this observation single-handedly links together the multiple theoretical foundations of this study. There is Vygotsky's notion of 'inner speech', constructivism's powerful precepts of negotiation and consensus through discourse and the overarching collaborative peer interactive learning environment facilitating this entire process. Complex yet simple, comprehensive yet summative, a practical piece of research coming together in such a way as to facilitate learning and teaching.

From the perspective of a practitioner, some research carries little credibility. Researchers who set up experiments with very narrow foci remove the classroom replicability factor from their work. Certainly other researchers may revere what they have done, however practitioners look for research which they themselves can relate to and hopefully apply to their own teaching situations. This study aimed to take ideas suggested by research and apply them to a 'normal' classroom situation across a broad range of curriculum tasks.

Chapter Summary

This chapter has described the multiple theoretical perspectives which informed this study. These perspectives have been under consideration by myself for over ten years as my earlier studies emerged and my experience as a practitioner grew (Ireland, 1986). The next natural step was to focus my thoughts into a specific course of action which manifests itself here in this research. In this literature review we have examined many facets of mathematics education, from those of international significance and those of national (Australian) significance, to those of local significance which have influenced the formation of this research. We have been informed about the many aspects of collaborative group work which have guided the development of the learning environment implemented in this study. The links between research in mathematics education and research based on Vygotskian principles were established, and then we embarked on a detailed examination of the Vygotskian perspectives which played a role in forming the theoretical base for this
study. Next we investigated the role of constructivism in this research. Touted as "a theory of knowing" (von Glasersfeld, 1993, p. 24) constructivism is a new term for an old practice, at least from the point of view of many practitioners. Thus our examination of constructivism noted how it had evolved from its radical beginnings, through a social phase, into a socio-cultural phase (from which this study drew its influence), and on to the emergent phase. Many facets within our constructivist journey impacted on this study, from the importance of prior knowledge and the role of discourse in learning, to the power of the social milieu in aiding knowledge construction and understanding. By examining the literature informing this study I outlined the theoretical background to my implementation of a collaborative peer interactive classroom-based learning environment in a first year high school mathematics class.

The next chapter examines the literature supporting the methodology adopted within this study. It includes facets of ethnography, action research and learning environment research. Further, Chapter 3 describes the setting-up of the study, including the process of forming the student groups.
CHAPTER 3

METHODOLOGY

Introduction

Many facets of methodology are examined in this chapter as we continue to share the personal journey that constitutes my study. The literature played a significant role in the interpretive processes in which I engaged and hence we start with a review of the ethnographic methodology upon which this study is based. After establishing my ethnographic perspectives we will see how these views evolved into a teacher-as-researcher focus. We will examine the methods utilised in collecting the data, explore the research site dynamics and study the structures of group formation and participant roles. These theoretical perspectives will be followed by the outline of the implementation processes which I invoked.

Why an ethnographic approach? I wished to view myself and my implementation of a collaborative peer interactive classroom learning environment in relation to the world of mathematics education research at large. For this to be the focus of my study I utilised qualitative inquiry techniques which enhance "the critical and intellectual dimensions of human thought" and enabled me as researcher to view myself "in relation to the larger world" (Edson, 1988, p. 45). This 'noble quest' was tempered by the reality of teaching and researching in a normal classroom situation, and yet this simply enhanced the appeal of an ethnographic approach, for as Vasta notes "in the naturalistic - observational approach, structure is sacrificed for realism" (Vasta, 1982, p. 2). The structure to which Vasta refers, is that typically found in traditional experimental or quantitative research and while this may not guide the ethnographic or qualitative research process, such techniques do have theoretical and practical structures upon which researchers can develop a methodology.

The dilemma I faced in pursuing pedagogic reality and objective truth in my research was that "most educational research is perceived by teachers as irrelevant to their daily working lives" (Cochran-Smith and Lytle, 1992, p. 304). This is my 'reality'. I am a teacher working with teachers. While my research must conform to the established norms for such activity I also wanted it to be as 'real' and practical as possible. However, much reported research suggested that this was going to prove difficult for "there is an apparently widespread view that educational research is of little relevance to practice" (National Board of Employment, Education and Training.
Australian Research Council. Discipline Research Strategies [NBEET], 1992, p. 9) for "research results are rarely functional in or applicable to real classrooms" (LeCompte and Preissle, 1993, p. 355). However, Chambers suggests that "there has been a pervasive misunderstanding in research on teaching" and argues for "researchers to embed their work in a practical theory of pedagogy, one which takes account of the real world of teaching" (Chambers, 1992, p. 245). In my study I am constructing my interpretation of my class's learning environment as I believe it is important to value a teacher's classroom experience since "teachers spend their working lives where the vital evidence must be sought, in the classroom" (Jackson, 1981, p. 52). I would not go so far as to say that "experimental studies conducted in laboratory settings cannot provide teachers with effective tools for carrying out the instruction task" (Blaye, 1990, p. 55), but I believe we must also acknowledge that effective tools for teachers can come from effective studies in the classroom, such as mine. This may seem a highly subjective analysis and one lacking the objectivity required to qualify as meaningful research, but such problems of objectivity are false according to noted British researcher Lawrence Stenhouse.

Any research into classrooms must aim to improve teaching. Thus any research must be applied by teachers, so that the most clinically objective research can only feed into practice through an interested actor in the situation. There is no escaping the fact that it is the teacher's subjective perception which is crucial for practice since he is in a position to control the classroom. We are concerned with the development of a sensitive and self-critical subjective perspective and not with an aspiration towards an unattainable objectivity (Stenhouse, 1975, p. 157).

The solution to my dilemma then lay in adopting a teacher-as-researcher methodology encompassing the practices of qualitative research techniques, for as Gallagher (1984, p. 10) remarks, "the best way to learn how to do ethnography is to do it".

Telling my story, as I carry out and report on my research as a teacher, follows a long tradition of over 25 years of similar work. Carter's research, reported in 1993, exemplifies this tradition. Carter, (1993, p. 8) notes that "interest in teachers' stories is closely linked to the emphases on reflection in action (Russell and Munby, 1991), and teachers-as-researchers (Carr and Kemmis, 1986; Cochrane-Smith and Lytle, 1990)". That the action research and teacher-as-researcher movements can be traced back to the work of Stenhouse (1975) and others seems to have eluded many other groups, particularly some in the United States. In the same year as Carter's comments, Patterson and Thomas (1993, November, p. 1) remarked that "there is a
growing concern that the voices of classroom teachers are absent from published accounts of educational research". This concern and lack of awareness can be addressed by studies such as mine which give voice to the teacher and the students.

The multiple theoretical perspectives which framed my research were put to the test in the classroom through utilisation of an action research methodology. "Action research lends itself well as a research method for teachers since it is easier to carry out in the classroom while teaching than traditional research, yet has many of the strengths of traditional methods" (Street, 1986, p. 126). When such methods were first explicated by Stenhouse in 1975 he encouraged teachers to report their own work so that case studies would accumulate. These case studies would then enrich and enlighten the more theoretical and laboratory-based forms of research. By examining their own situations teachers are able to replicate and extend previous studies. "The most valuable way in which existing research can be used is by practising teachers deciding to 'try it and see' within their own school contexts" (Lolley, Davies and Scott-Hedgets, 1987, p. 46). As Stenhouse noted:

It is important to make the point that the teacher in this situation is concerned to understand better his own classroom. Consequently, the teacher need not generalise beyond his or her own experience. In the teacher's context, theory is simply a systematic structuring of their understanding of their work (Stenhouse, 1975, p. 157).

The fundamental outcome or generalisability of my study lies in the duplication of the ideas by others. "Proving or disproving theories or providing generalisable results is not necessary. The centrality of the practitioner to the research is seen to provide a much needed emphasis on pedagogical research" (Street, 1986, p. 126). Bassey considers that:

there are two kinds of pedagogical research that attempt to improve the quality of teaching and learning -

(i) The Search for Generality: this kind attempts to produce general statements about teaching and learning.


Classroom research findings should be reported because doing so broadens the case study data base from which other teachers can draw information which may assist them in their implementation of similar situations. In each of Bassey's cases there is "no attempt to generalise the findings beyond the classroom, but there is recognition that there may be aspects of the results which stimulate other teachers to try something similar" (Bassey, 1986, p. 21).
Action research or teacher-as-researcher studies have secured their own place in the education research literature. Such works have established significant credibility among practicing teachers, most of whom "do not view the action research movement as a substitute for, or necessarily competitive with, mainstream educational research" (Hustler, Cassidy and Cuff, 1986, p. 207). Some researchers acknowledge that action research has a special role to play in educational research. "The action research movement with its 'teacher-as-researcher' emphasis has done much to dispel the polarisation or gulf existing between theory and practice, a gap that has always been hard to bridge" (Lovitt, 1993, p. 35-37). Action research has done much in the form of creating a sub-culture in educational research but there are still many mainstream sections of educational research which have yet to acknowledge the value and expertise encompassed in teacher research. In Australia, the action research movement has established a strong following among a variety of educational researchers. Here in my State, the government department responsible for education has long encouraged teachers to engage in action research because of the perceived benefits and outcomes which such inquiry offers teachers, students and the education system.

Any systematic classroom investigation is a method of improving teaching practice and therefore student learning. The main aims of undertaking such investigation (or action research) are to improve specific aspects of practice, and at the same time heighten the understanding of the improvement and its implications, through reflection upon its nature, causes and effects. The importance of the reflexive nature of this sort of investigation cannot be over-emphasised, and nor can the value of sharing reflection with other teachers engaged in a similar investigation. When selecting a course of systematic classroom investigation, teachers will need to isolate just what it is that they consider specifically needs investigating and improving, and then use their reflection to enable them to incorporate their findings into future practice (EDWA, 1984, p. iv).

This passage overviews the process which I put in place as I embarked upon my study. Improving practice, learning, reflection, sharing and communication are all potential benefits to be gained from engaging in action research.

In adopting an action research methodology incorporating ethnographic techniques, my research journey met with several challenges which were overcome by considering the context of the setting for the study. I view education as intersubjective activity and my participant observer role within my study identifies my work as interpretivist inquiry. "Interpretivist researchers try to understand
particular educational situations from the point of view of the actors in them" (Soltis, 1992, p. 620-621). It is subjective, but having defined the beliefs and values that my research is founded upon opens up the subjectivity as a basis from which my data, results, interpretation and conclusions can be and are drawn. It also illustrates the nature of my research as being for comparison and not for generalisation. "This approach sought data, not evidence. What was collected was a range of interpretations from a variety of perspectives in an attempt to understand better the complex human arena, rather than proving some aspect of it" (Weeks, 1993, November, p. 3). Ensuring the warrant of the collected data and the interpretations drawn from it required meeting accepted standards of practice for such research. "Ethnography has to be on a daily basis to get to know the situation" (Howard, 1995, July) and my study was carried out daily which enabled me to develop my active listening and observation research skills. Indeed, "it is critical that observations and interactions with the groups being studied occur over a long duration" (Gallagher, 1984, p. 7) and my study ran for six months.

Using the literature I have reviewed as a researcher, and the practical classroom skills I have acquired as a teacher, I am able to establish a shared vocabulary linking the theoretical background of my study, and the methodology, with its practical application in my classroom. "It is this language that can be used to recognise, collect and document illustrative classroom vignettes" (Lovitt, 1993, p. 44-45). Such vignettes or narratives play a critical role in explicating my 'teacher' observations and linking these to my 'researcher' ideas. In presenting this research I outline the contexts and perspectives of my writing which, together with the contexts and perspectives of the reader, bind the interpretation of the data and results. "Narratives are not completely objective but are bounded by the researcher's perspectives, the research questions, as well as our ability to interpret the words and actions of our research subjects" (Jones and Carter, 1994, p. 607). This all presumes, of course, that I am able to exchange my teacher persona and researcher persona at will. Patton believes that:

the flexible, responsive evaluator can make mind-shifts back-and-forth between paradigms within a single evaluation setting. In so doing, the evaluator can view the same data from the perspective of each paradigm, and can help adherents of either paradigm interpret data in more than one way (Patton, 1988, p. 127).

This in fact describes the natural process of teaching where the educator is able to illustrate a concept from a variety of different perspectives which facilitates learning among the variety of student perspectives present in the classroom. Thus, as an experienced teacher, I already possessed many of the skills I required to engage in
this study. In the next section we examine specific aspects of ethnographic research techniques applicable to the study.

The ethnographic nature of the research

"Ethnography can lessen the distance between theory and practice. It provides teachers with greater control over everyday events and hence increase their capacity to alter their own practice and instigate educational change if they wish to do so" (Woods, 1988, p. 97-98). I certainly wished to do so. One of my primary objectives, for myself and for others, was to transform the theoretical paradigms guiding my study into practical forms in my classroom. This meant I had to accommodate new approaches and practices into my teaching routine, and the classroom was the only venue where I could do this.

New teaching strategies are extremely difficult to learn and to set oneself to learn, especially when they cut across old habits and assumptions and invalidate hard-won skills. Nevertheless it is true that strategies can only be developed in the classroom (Stenhouse, 1975, p. 25).

To some degree teachers feel that they must surrender many hard-won skills when they adopt some of the new approaches, such as constructivism, put forward by educational researchers. I too felt this way at the beginning of my study. Classroom development of strategies like those utilised in my study are ways by which teachers can effectively implement and make practical use of educational theories.

"The results of interpretive research are of special interest to teachers, who share similar concerns with the interpretive researcher and who can do ethnographic research by reflecting on their own practice" (Erickson, 1986). Teachers are very much aligned with this approach for most believe, as does Brown, that "a strictly laboratory-based psychological theory of learning is, and always was, a chimera" (Brown, 1994, p. 6). However, classroom-based research cannot always adopt the 'pure' ethnographic or qualitative approach and frequently becomes quasithinographic. "Quasithinographic studies are those which use traditional ethnographic concepts and methods but combine them with other methods and theoretical frameworks in an interdisciplinary approach" (LeCompte and Preissle, 1993, p. 9). I founded my approach on widely diverse theoretical frameworks and utilised several methods which categorises my research as quasithinographic. I have explicated my values, beliefs and the influences of prior work on my study's development which highlight how this research evolved into a quasithinographic study for, as Myrdal (1969) showed, "the researcher cannot be free from his or her
own values and political convictions, but can arrive at more valid conclusions and gain in credibility by making their value premises explicit and by making clear what those biases were" (Myrdal, 1969, in Husen, 1994, p. 5053).

**Why an ethnographic research focus?**

Ethnography can be based in practical situations and this facility has led to widespread use of ethnographic methodology in educational research. My study is focused and centred on my classroom. "Ethnography can provide understanding of the 'real world of schools' which can be used by experimentalists as hypotheses worthy of validation or refutation" (Gallagher, 1984, p. 9). In addition I required input from the participants in the study - the students in my classroom - which an ethnographic approach also accommodates. Ethnographic research provides "information that will allow the investigator to 'make sense' of the world from the perspective of the participants" (Eisenhart, 1988, p. 103-104). In an implementation such as mine, utilising the students' viewpoints provided vital feedback to the process of developing a collaborative peer interactive classroom learning environment. "As teachers, we can use this vantage point to review our own understanding" (Hustler et al., 1986, p. 8). This idea is one of the fundamental premises upon which I based my classroom environment, namely, 'listen to the students'.

Classroom-based ethnographic style research is not without its perils. In parallel with all ethnographies, the challenge to make the familiar strange and the strange familiar is ever present. When teachers study learning and teaching environments we encounter very little that is strange, in the ethnographic sense, and making these familiar is not of great concern. We are more focused on "making the familiar strange" (Gallagher, 1984, p. 2). This is because the environment we are researching is in fact very familiar to us as our place of work. In my study, by implementing a collaborative peer interactive learning environment, an environment new and strange to me, I did not leave my setting familiar but made it strange, (different from my usual practice). As I applied new and innovative practices to my own teaching I constantly reflected on the success of this implementation. What was familiar to me (teaching) had become strange because of the 'new' approach and the ongoing data analysis this involved. What was strange to me (research in my classroom) became familiar through constant practice and reflection during the implementation.

Other complexities plague the classroom-based ethnographic research model. Some researchers are concerned that when studying schooling "it is necessary to participate on a regular (if possible, daily) basis with the people in the school so that you are
viewed, to the degree possible, as a member of the group and not as an outsider" (Gallagher, 1984, p. 5). This was not a problem in my study as I was the classroom teacher attached to the group of students being studied. We worked together on a daily basis. The only potential problem was that my work as a teacher could interfere with my work as a researcher. Teaching certainly came first as it was my duty of care and my employer's expectation that I would carry out my teaching duties as required.

A rarely expressed reality of classroom intervention relates to the impact of the school community on the classroom community.

The environment of the classroom and of schools, in general, is extremely complex and unpredictable. My best-laid plans were often at the mercy of student absences, district testing, field trips in other classes, and special assemblies. These conditions forced me to re-think and relinquish traditional concepts of 'control' - a fundamental element in the design, procedure and analysis of research (Wong, 1995, p. 28).

Data from my study will reflect such circumstances of 'in-the-field' research plan modification. Students are people too! Researching my classroom required the permission of the parents and the students. "In the study of children researchers may request indication of children's assent to participation for which parents have given consent" (LeCompte and Preissle, 1993, p. 108). Indeed this was the case in my study. The parents were informed of the research and its purpose and of their ability to interact with any facet of the study or if they desired, to withdraw their child from the study. The students were also told of this and reminded on several occasions through the implementation that they were allowed to request to be placed in another identical status class if they so desired.

The difficulties of working in the practical situation of the classroom were not insurmountable for the purpose and outcomes were of significance to all involved, students and teacher. We all wanted to succeed in developing an effective collaborative peer interactive classroom learning environment. In conducting our ethnographic research into our classroom practice we hoped to provide answers of use to ourselves and to others. Answers that are needed in educational research for reasons such as:

- the need to explore the invisibility of everyday life
- the need for specific understanding through documentation of concrete details of practice
- the need to consider the local meanings that happenings have for
people involved in them
- the need for comparative understanding of different social settings
- the need for comparative understanding beyond the immediate circumstances of the local setting (Erickson, 1986).

Ethnography in the classroom provides the opportunity for these needs to be addressed along with those of the participants, the students.

**Qualitative or Quantitative**

'Ethnography' often implies 'qualitative' to many researchers, however a more enlightened approach to mixing research methodologies has emerged in recent times. This study was influenced and informed by several theoretical paradigms, the most important of which was in taking a Vygotskian perspective to learning and teaching. The implication of this position was that experimental results will be qualitative as well as quantitative in nature. Detailed descriptions, based on careful observation, will constitute an important part of experimental findings. To some, such findings may seem merely anecdotal; Vygotsky maintained that if carried out objectively and with scientific rigour, such observations have the status of validated fact (Cole and Scribner - introduction, in Vygotsky, 1978, p. 14).

The methodology for this study undertook to combine aspects of qualitative and quantitative research techniques. "It is all right to mix quantitative data in to a qualitative study" (Ely, Anzul, Friedman, Garner and McCormack Steinmetz, 1991, p. 97). Indeed, "qualitative / quantitative research can co-exist and do not come from incompatible frameworks" (Phillips, 1986), and "combining qualitative and quantitative methodologies is a desirable future direction in education research" (Kyle, 1994, p. 695-696).

Thus it was that this study took on a combined methodology of mixing quantitative techniques and data with a qualitative approach to classroom enquiry. However, I went even further in developing the methodology by adopting an action research, teacher-as-researcher stance for the implementation model of my study. "It is by no means impossible to combine quantitative, qualitative and action research approaches in the one study" (NBEET, 1992, p. 59). Hence, I adopted a highly 'collaborative' stance in my evolution as a classroom researcher. "Few researchers can be expected to master and pursue both quantitative and qualitative methods. They should bring a collaborative attitude to research" (Howe, 1988, p. 15). The
methodology developed for this study shows that the researcher clearly believes that "the quantitative-qualitative debate is an invention" (Howe, 1992, p. 254).

My study occurred in its natural setting and records the changing attitudes of the students towards working collaboratively as their attitudes developed through the implementation. Although a study such as mine is 'true' only for the time and place of the study, it has more than singular significance since it supports many findings from other studies and could potentially be supported by findings from supplementary studies.

"Other studies can be regarded as supplemental studies rather than replicative studies" (LeCompte and Preissle-Goetz, 1982, p. 37). The findings are therefore "both confirmatory and seeking confirmation" (Guba and Lincoln, 1988, p. 108). That the findings are 'unique' is not disputed. That such uniqueness lessens the significance of the findings is disputed.

When phenomenographers present their findings, someone usually asks: 'Would another researcher working independently arrive at the same set of categories if he or she were studying the same data?' On the surface, this appears to be a reasonable question. After all, research results are supposed to be replicable. However, two issues are buried in the question. One concerns the process of discovery: Would other researchers find the same conceptions or categories if they were doing the study for the first time? (Analogously, we might ask, "Would two botanists discover the same plants and species if they independently explored the same island?) (Marton, 1988, p. 148).

The problem is even more complex when one realises that, in the educational setting, the 'plants' (in our case students) have been altered or affected, we assume. That is learning has occurred, the students have experienced situational / environmental influences, maturation, and so on. So the second researcher (botanist / phenomenographer / educational researcher) would not in fact be exploring the same 'island'!! So only they who are first on the scene have any chance at observing what they who were first on the scene might observe, for after that the scene is irreversibly altered. These important and significant immutables need to be borne in mind when considering the integrity of a study such as this.

I was not able to test (experimental research measures) in the context of my study because the intervention was performed on the whole class, and so we had no way of knowing or assessing progress for an intervention versus non-intervention situation. Another class or different teacher would be equally unsuitable for comparative purposes due to the different student and different teacher factors. One form of
comparison does exist for, as the teacher researcher, I carried out the intervention with only one of my five classes while my other classes experienced 'traditional' teaching practices. It is therefore worth noting that during the course of the year I found more and more of the practices from the intervention creeping into my other classes and thus the changes grew well beyond one class. The data also shows that several times I was found to be back in 'traditional' mode when working with the intervention class.

Reliability, validity, triangulation, generalisation, objectivity

Reliability refers to the extent to which we can gain the same outcomes from one stage of a study to the next stage or from one complete study to the next study. To acquire external reliability a study should:

• acknowledge the researcher's social role within the research site
• delineate the people who served as informants and describe the process invoked in their choice
• specify the social settings where data are collected
• outline the 'theoretical premises and defining constructs that inform and shape the research' (LeCompte and Preissle-Goetz, 1982, p. 39)
• identify and describe the strategies used to collect data and

This researcher's social role within this study's research site was that of teacher in the classroom. The informants were the students of the class under observation, along with two researcher colleagues who video taped and observed some lessons and interviewed selected informants. The 'informants' were placed in this, my class, by the school authority. No special selection processes were invoked. The data was collected from my classroom teaching situation which was operating under the influence of all of the theoretical paradigms explicated earlier in Chapter 2. The data collection strategies and methods will be described later in this chapter.

The wealth of primary data reported in this study is limited only by the externally imposed limitations guiding the production of this document. That which is presented is 'rich' and should "provide the reader with multiple examples from the fieldnotes" (LeCompte and Preissle-Goetz, 1982, p. 41) which will enhance this study's credibility and internal reliability. Independent researchers would discover the same phenomena or generate the same constructs if they shared the same background and belief system as I, the original researcher.
Validity indicates whether we are measuring what we think we are measuring using our data collection and analysis procedures. Internal validity is enhanced through longevity at the research site while external validity attempts to test the extent to which "the abstract constructs and postulates generated, refined, or tested by scientific researchers is applicable across groups" (LeCompte and Preissle-Goetz, 1982, p. 43). This study was implemented for a full semester or six months giving it significant longevity for such research. Internal validity, the match between what is assumed to have occurred and what is represented by the research, is difficult to conceptualise as I do not think I assumed anything occurred other than what the observations recorded. Perhaps one assumption is that the students learned the mathematics, or some of it, presented each day in class. The extent to which this study is applicable across groups is determined by how similar such groups are to the group researched in this study. External validity is the extent to which this representation applies to other occurrences. It is difficult for a constructivist to be concerned with the match between conclusions reached and some assumed 'reality' when they do not really believe in the existence of such a 'reality'. I believe this study has sufficient commonality with other similar situations to be transferable and or comparable and thus to have an acceptable level of external validity. The best validity check comes from "the sensitive, intelligent fieldworker armed with a good theoretical orientation and good rapport working in the field over a long period of time" (Kirk and Miller, 1986, p. 32), which are all features to be found in this study.

Ensuring acceptable levels of reliability and validity is a process of implementing the required multiple data collection strategies into the design of the study. The process is known as triangulation. Denzin (1978) identified four types of triangulation:

- (i) data triangulation - the use of a variety of data sources in a study
- (ii) investigator triangulation - the use of several evaluators
- (iii) theory triangulation - the use of multiple perspectives for interpretation
- (iv) methodological triangulation - the use of multiple methods, for example interviews, observation, questionnaires, and documents (Patton, 1987, p. 60).

My study used the researcher, two collaborative researchers, and the participants to collect data using several different methods from a variety of sources giving the data multiple perspectives for interpretation. The design and execution of this study has certainly provided adequate triangulation of the collected data.

In addition to these strengths we have the added feature of the data, in its many forms, being collected over a long period of time. "Many experts indicate that triangulation characteristically depends on the convergence of data gathered by different methods, such as observation and interview. We have found that
triangulation can occur with data gathered by the same method but gathered over time" (Ely et al., 1991, p. 97). One must be cautious in accepting such claims however because it is possible that the triangulation from prolonged observation may, in fact, just be a matter of the observer's mind having become accustomed to seeing set things. Hence it is important that a variety of methods of data collection be utilised. Mathison also supports the enhancement of triangulation through "prolonged engagement in a site" (Mathison, 1988, p. 13). For Mathison however triangulation should not be pursued for technological reasons (enhancing reliability and validity) but rather triangulation should be based on honest and thorough interpretation of the findings.

There seems little reason to pursue a triangulation strategy based on the assumption that bias will be cancelled out. Triangulation provides evidence. Triangulation does not make sense of some social phenomenon. The value of triangulation lies in providing evidence such that the researcher can construct explanations of the social phenomena from which they arise (Mathison, 1988, p. 14-15).

... triangulation is a state of mind. If you self-consciously set out to collect and double-check findings, using multiple sources and modes of evidence, the verification process will largely be built into the data-gathering process, and little more need be done than to report on one's procedures (Miles and Huberman (1984, p. 235) in Mathison, 1988, p. 16)

Triangulation ensures the integrity of the data collected and analysed in this study while reliability and validity ensure the broader applicability and relevance of these outcomes. All focus on ensuring comparability with other studies and that this study can be effectively replicated. However, not all replications support a theory or outcome in the same way. "Replications under conditions that exactly repeat the original study are most useful for establishing reliability. When conditions vary, successful replication contributes to generalisability. Similar results under different conditions illustrate the robustness of the findings" (Firestone, 1993, p. 17). Perhaps more important to a study of this nature are the concepts of translatability and comparability. "Translatability requires that methods, categories and characteristics of phenomena and groups be identified so explicitly that comparisons can be made across groups and disciplines with confidence" (Borman, LeCompte and Goetz, 1986, p. 48). "Comparability requires that standard and non-idiosyncratic terminology be used wherever possible and that the boundaries and characteristics of what is studied be made crystal clear" (Goetz and LeCompte, 1984).
Comparability is the degree to which the components of the study, including the units of analysis, concepts generated, population characteristics, and setting, are sufficiently well described and defined that other researchers can use the results to compare to other studies addressing related issues. Establishing the comparability of a study makes it scientifically useful (LeCompte and Preissle, 1993, p. 348).

"Translatability is related, but distinct; it is the degree to which the researcher uses theoretical frames, definitions and research techniques accessible to and understood by other researchers in the same or related disciplines" (LeCompte and Preissle, 1993, p. 348). This study is highly descriptive and therefore highly comparable. All of the theoretical frames in this study are well known in the research community and so I consider the study as a whole to be highly translatable.

A facet of my study worth emphasising here is the nature of research such as this. My study can never be replicated exactly because the students grew up and learned something so they are no longer viable participants for such a study and no comparison to a control group was possible because these participants were a unique group of individuals and could not simultaneously be involved in a treatment - control environment. Thus this work holds a unique position but, as the literature attests (LeCompte and Preissle, 1993), such perspectives are still valuable for comparison and for the way they illuminate theory through the practical application of many ideas. The obligation of the researcher in such situations is to communicate what they have learned. Credibility and viability become the new 'test measures' for interpretive research compared to the traditional standards of reliability, validity, reflectivity and generalisability. Generalisation may now mean apply what we have learned to different contexts across different times. This approach to research, which engages the practical environment of the classroom, is emerging as a valuable tool for the research and teaching (practitioner) communities. Known as action research, it seems important for the research community to have this form of research play a more enduring role in teachers' professional lives. The research community will benefit if it can enhance the action research skills of every teacher. One way to achieve this might be to make action research "a part of every teacher's job description and its successful prosecution part of the teacher's career structure" (Desforges, Cockburn and Bennett, 1986, p. 72).

As this research is teacher research it can be argued that teachers require and deserve a study with integrity, one that is valid, reliable and easily compared and transferred to their own situation. This pursuit is for a level of objectivity which teachers can empathise with and share. "Objectivity comes from teachers sharing and discussing
their interpretations. Traditional academic research is of no help as its jargon is a barrier to teachers sharing understandings” (Hustler et al., 1986, p. 8). From this point on the ‘jargon’ best diminish.

**Teacher-as-Researcher**

The functional model for the research contained in this study is one based on a teacher-as-researcher approach - an action research model. Action research is about the collectivisation of problems, facing teachers across curriculum areas and teaching levels, and their solutions. It is an approach to "improving education through change, by encouraging teachers to be aware of their own practice, to be critical of that practice, and to be prepared to change it" (McNiff, 1988). Action research, using the teacher-as-researcher, allows the focus to swing onto real classrooms operating amidst the daily routine of school life. "Action research provides teachers with an opportunity to apply the findings of 'traditional' research to their own situations and to adapt theory to practice. It brings research (and the findings of research) into classrooms where it is needed" (Anders, 1966, p. 318). Wild (in Stenhouse) recommends that 

"(i) research should be located in the reality of the particular school and the particular classroom and that (ii) the role of the teacher as a researcher must relate closely to the role of the teacher as a teacher“ (Stenhouse, 1975, p. 133). Action research actively involves teachers as participants in their own educational process. "Action research is research WITH rather than research ON" (McNiff, 1988, p. 2-4). Kemmis goes further suggesting that "teachers doing action research should do it with their students” (Kemmis, 1995, March). This study is squarely located in a particular classroom operating within the reality of the particular school and is focused on the students and their perceptions; a strong model of teacher-as-researcher action research.

That teachers can do this type of research was never in question in the formulation of this study. "All educators can, and perhaps should, be researchers in their own setting" (NBEET, 1992, p. xiv). "The most important lesson is that teachers are able to do this kind of research as part of their own practice" (Pateman, 1989, p. 38). A purpose is still required however. As a teacher I do not add to my work load by arbitrarily performing ad hoc pieces of 'research'. Engaging in action research provides me with the opportunity to examine an issue which is of importance to me and which I believe is of importance to other teachers. That is, I can make a difference. I can contribute to educational research. "Teachers can conduct useful and rigorous research, thus not only effecting their own professional development but also contributing to the knowledge and expertise of others. A strong feature of
such projects is their extended time frames" (Mousley, 1992, p. 106). A feature of this study is its long or extended time frame which Mousley above highlights as a strength for such research.

There are other 'strengths', apart from reliability, validity and similar procedures, which action research brings to the research process.

Unlike traditional researchers, action researchers do not research other persons' practice but their own. It follows that, by investigating a situation they themselves are deeply implicated in, they also scrutinise their own contribution to this situation and, consequently, their own competency and self-concept. This is what gives action research rigour and seriousness (Altrichter, 1993, p. 50).

One particular facet of teacher-as-researcher action research that keeps the researcher honest and ensures rigour is that they are "researching and developing themselves for they have to live with the effects of their theories and experiments" (Altrichter, 1993, p. 50) long after the research is completed. The principal focus of such research is the improvement or enhancement of practice in such a way that it will be useful for others as well as the teacher researcher. "If emphasis is placed on action research, the degree of precision of the research findings is not particularly important as long as the action is being steered into desirable channels" (Chein, Cook and Harding, 1948). Regardless of the outcomes, the teacher researcher can rest assured that "some aspects of what occurs in any human teaching situation will generalise to all other situations of teaching" (Erickson, 1986).

Action research aims to help practitioners investigate the connections between their own theories of education and their own day-to-day educational practices; and to integrate the research act into the educational setting so that research can play a direct and immediate role in the improvement of practice by assisting practitioners to become teacher researchers (NBEET, 1992, p. 65).

This synthesis statement highlights how, in a study such as this, teachers can invoke educational theory in the context of their daily practice to supply immediate feedback about their learning and teaching environment. "Many action research initiatives have aimed to improve school and classroom practice" (Elliott, 1985; Oja and Smulyan, 1989; Cochran-Smith and Lytle, 1990, p. 3) while "increasing understanding and informing the decisions of teachers" (Nixon, 1981, p. 6). "Action research may also bring about a modification or elaboration of theories of teaching and learning" (Nixon, 1981, p. 6) and "contribute to knowledge about teaching and research itself" (Elliott, 1985; Oja and Smulyan, 1989; Cochran-Smith and Lytle,
Action research offers teachers a unique perspective. Immersion in their field allows teacher researchers to "develop unique views or knowledge about schools and classrooms" (Wagner, 1993, p. 14) as they deal "with a unique child in a unique teaching-learning situation" (Husen, 1994, p. 5054). This study is an example of research into just such a 'unique' setting.

Theoretical Background

In an attempt to summarise this discussion of the ethnographic research model, which engages qualitative and quantitative techniques while utilising an action research teacher-as-researcher approach, let me now examine further theoretical support for the methodology adopted in this study.

Maintaining a focus on the theoretical paradigms which inform this study was of paramount importance to me and my methodology was designed to allow these perspectives of influence to flow freely in the implementation of the research. Both a constructivist and a Vygotskian perspective are well served by an action research methodology. "Action research acknowledges that social reality is constituted by the contributions of different actors who all hold - sometimes differing - interpretations about what is happening" (Altrichter, 1993, p. 47). My approach recognises that to further develop pedagogic theories in mathematics education, a different form of fundamental analysis is required. By adopting a practical orientation to our research we can carry out research in a school through the analysis of units of the school system. Each unit designates a product of analysis that possess "all the basic characteristics of the whole" (Vygotsky, 1987, p. 46). Such a unit can be found in the form of a classroom, populated by the students and their teacher. Research has to take place in the classroom so that we can overcome the perceptions that "research results rarely are functional in or applicable to real classrooms" (LeCompte and Preissle-Goetz, 1982, p. 54). As a teacher researcher I felt best situated to carry out this, the first stage of discovery, in the further evolution of pedagogic theories of mathematics education. Action research was to be my 'vehicle of discovery'.

Action research is not new. It was initiated in the 1940's by Kurt Lewin and adapted by educators soon after, with examples of action research being prevalent throughout the 1980's, particularly in the work on teachers-as-researchers taking place in the United Kingdom. In my study the research is very similar to Lampert's (1990) in that I engaged myself in teaching while researching and collecting data using all of the techniques Lampert used and more.
Lampert engaged herself in the role of 'teacher-scholar', and as such she has been teaching mathematics in fourth- and fifth-grade classes while collecting data on her own teaching. Some of the data has consisted of audiotapes and videotapes of the lessons, classroom observations, samples of students' work in the form of notebooks and homework, and fieldnotes on the planning and implementation of lessons (Koehler and Grouws, 1992, p. 122).

"Lampert (1990) points out that her methods are a blending of action research and interpretive social science" (Koehler and Grouws, 1992, p. 122). This is perhaps the unique facet of Lampert's work that is worthy of high acclaim. My study attempts to follow Lampert's lead in developing this approach to mathematics education research.

Many great research initiatives have come and gone in the past three decades and yet teaching has changed little. While not promoting action research as "a panacea for all educational ills for there are some good things that it cannot do or even pretend to do" (Anders, 1966, p. 317) there is a need for the education research community to embrace such research more readily and elevate its status, for it offers a way out of the stagnation which presently entraps the education research community. "It is difficult to see how teaching can be improved without self-monitoring on the part of teachers. A research tradition which is accessible to teachers and which feeds teaching is needed if education is to be significantly improved" (Stenhouse, 1975, p. 165). The virtues of teacher-based educational research are distinct from those of external researcher-based research. Both have a role but the latter has dominated for a long time. The true aim of action research is to have the teachers do it themselves, that is teacher-as-researcher, a long existing practice. "It is not enough that teachers' work should be studied: they need to study it themselves" (Stenhouse, 1975, p. 143).

Self examination, interpretation and understanding enhance qualitative research. It is important that I fully examine my place in all of this.

Teachers who do research will never approach the act of inquiry without an agenda - they will be prejudiced because they live and work in the schools. These prejudices are not an impediment, however, they are part of the relevant understandings teachers have acquired from their experience. In conjunction with their classroom inquiry, these understandings can lead to more sophisticated reflection and reflective action (Kincheloe, 1991, p. 102).

Thus I am aware of the various facets of my experience which influence my actions and my research approach. This understanding adds to my reflective processes as I
engage in my action research. Still other aspects of my study further enhance the credibility of work such as this. "To the extent that researchers have become part of the community and have the same experiences as natives do, the quality of their data is improved" (LeCompte and Preissle, 1993, p. 92). I was a central part of the 'community' with many identical experiences to those of the participants (students) throughout the study. "Above all, ethnographers must work in settings where behaviour occurs naturally. Over a sustained period of time, they must maintain constant interaction with participants" (LeCompte and Preissle, 1993, p. 95). Self awareness, engagement on site, constant interaction and an implementation duration of six months. These are factors which further strengthen the methodology of my study.

In developing their working definition for teacher research, Cochran-Smith and Lytle (1990, p. 3) came up with "systematic and intentional inquiry carried out by teachers". After working with this for a few years they developed a stronger position which was:

that research by teachers represents a distinctive way of knowing about teaching and learning that will alter, not just add to, what we know in the field, (Cochran-Smith and Lytle, 1990; Lytle and Cochran-Smith, 1991). As it accumulates and is more widely disseminated, research by teachers will represent a radical challenge to our current assumptions about the relationships of theory and practice (Cochran-Smith and Lytle, 1992, p. 298).

"Action research in the classroom starts with attempts to uncover 'matters of concern' as perceived by teachers, rather than 'problems' as perceived and conceptualised by those not directly involved in the day-to-day business of classroom life" (Cummings and Hustler, 1986, p. 38). The realities of working in a school where 'matters of concern' arise all of the time requires that we place teachers in charge of the action research agenda rather than educational researchers. Teacher knowledge, based on teacher research such as my study, can contribute greatly, and possibly more effectively to the educational research base. It has the potential to give a clearer and different view of educational practices to that which has been derived by traditional research techniques to date.

In the sections which follow I shall delve more deeply into specific details of the methodology used in this study and the associated data collection strategies.
Data Sources and Processes

In embarking on this implementation I was required to adopt my 'field' researcher methodology to accommodate the working cycle of the teacher in the classroom. My fieldnotes, recorded from observation and audio tape, were to be my primary data source and I was to be a "complete participant" (Gold, 1958) in my role as the class teacher. These fieldnotes would form my "particular description" (Erickson, 1986) and my search for patterns would form my "general descriptions" (Erickson, 1986) or "vignettes" (Gallagher, 1984, p. 6). Linking these would be the "interpretive commentary" (Erickson, 1986) which synthesises the observations and theory in an endeavour to interpret and illustrate findings. This should all point the reader to those details that are salient for me and clarify my meanings and interpretations. Thus I have been careful to explicate my position both theoretically and practically to give the reader the clearest view of this research. This requires more than just my observations however. "Descriptions of classroom teaching are likely to be enhanced when multiple sources are used to collect evidence over fairly lengthy periods of time" (Anderson and Burns, 1989, p. 305). This study ran for all of first semester and engaged several data sources additional to classroom observations by the teacher. "Like university-based qualitative research, a strength of teacher research is that it often entails multiple data sources that can be used to confirm and/or illuminate one another" (Cochran-Smith and Lytle, 1990, p. 7). The sections which follow discuss these various data sources.

"Recording data is a central activity of ethnographers. The accepted method is in the form of fieldnotes" (Gallagher, 1984, p. 5). The fieldnotes in this study were constituted from in-class informal observations, "simple descriptions of several aspects of the child's activities usually made at relatively unsystematic intervals" (Vasta, Andrews, McLaughlin, Stirpe and Comfort, 1978, p. 163), and audio recordings of each lesson. "Teachers can learn a great deal about the individual student's involvement in the small group discussion simply by observing - by monitoring student talk in small groups" (EDWA, 1984, p. 27). This study incorporated both "active and passive forms of participant observation", (Everson and Green, 1986, p. 178), but I, as the class teacher, made mostly active types of observations. Fieldnotes can be qualitative (written), diagrammatic, even counting (quantitative). They are "records in everyday language of observed phenomena, methodological decisions, theoretical observations, and other relevant information" (Everson and Green, 1986, p. 179). These fieldnotes constitute the primary data source and as such their recording is vital to the study. Beasley suggests to teachers
that "they make brief notes during and after lessons and expand those notes into a more narrative form, if possible, on the same day as the observations" (Beasley, 1981, p. 378). Enright kept a diary. "I wrote this up daily, a task which required between two and three hours every evening" (Enright, 1981, p. 37). Enright "wrote the diaries while working full time in the classroom. Much that is valuable can only be carried out by the teacher who is working in the class" (Enright, 1981, p. 51). My method engaged me in maximum participation but still allowed me to make some recorded observations. Then, within seven hours, a review of the entire lesson for the enrichment of the observations was made. "A skilled observer may be using maximum participation to elicit rich data, which will be recorded at a later time" (LeCompte and Preissle, 1993, p. 204). This review detailed the participation and further enhanced the combination of researcher and teacher.

In addition to fieldnotes from observations and audio recordings of every lesson, this study made use of video recordings of some lessons, researcher colleague review of these video recordings and researcher colleague observation fieldnotes of other lessons and interviews where specific aspects were searched for. "Qualitative researchers may seek commentary from other researchers, mentors and colleagues as an aid in clarifying concepts, developing and refining questions, and regaining insight into phenomena" (Borman, LeCompte and Goetz, 1986, p. 44). One of the clear advantages evident from my study of the use of the video material was the richness which this medium gave in terms of supplementing the fieldnotes for that lesson. It really did "provide a zoom lens effect" (Stenhouse, 1975, p. 153). The videos from this study provided "samples of the student's activities, recorded as completely as possible over a limited, but systematic, period of time" (Vasta, 1978, p. 166-167). One problem which can arise with the use of such media is reactivity. "This means that the behaviour of the subjects sometimes changes when they know they are being observed" (Vasta, 1978, p. 178). The solution to this problem, which this study utilised, involved long term use of the video. "It has been noted that the reactive effects of observations sometimes decrease after a period of time" (Vasta, 1978, p. 178). Another technique utilised in this study was that of having an observer carry out set tasks aimed at probing and identifying greater detail related to my field observations. The observer can get answers to questions that the researcher does not have the time to obtain because of his other very demanding role as teacher. "A teacher who wishes to take a research and development stance to his own teaching may profit at certain stages in the development of his research by the presence of an observer in his classroom" (Stenhouse, 1975, p. 155). The colleagues and observers in this study were there to help me monitor circumstances within the study and thereby enhance the rigour of the evidence emerging from the data.
The principal source of quantitative data acquired in this study came from the surveys of the learning environment. Other quantitative sources include the tests and assessments the students completed over the course of the year. The learning environment surveys constitute "formal observations" (Vasta, 1978, p. 169). These measures were obtained to "encourage an active student voice in the classroom" (Tinto, Shelly and Zarach, 1994, p. 647). "Other methods of data collection (for example surveys) often supplement the corpus of data and contribute to triangulation. These materials, often quantitative, are used primarily to generalise an interpretation" (Eisenhart, 1988, p. 107). The learning environment surveys, along with the other data sources provide multiple perspectives of the data corpus. School-based tests, a requirement of assessment for this and all similar Year 8 mathematics classes at our school, were another source of data. Such events affect all classroom-based research projects. "All of the classrooms in which we have been working participate in the state mandated accountability testing" (Yackel, Cobb and Wood, 1992, p. 78). In the course of my study I collected together a considerable number of artefacts in the form of test papers, both individual and group-worked, examples of student work, survey question sheets and, of course, a marks record of each student's progress through the year. "Artefacts provide evidence for the topics and questions ethnographers address because they are material manifestations of cultural beliefs and behaviours" (LeCompte and Preissle, 1993, p. 216).

**Characteristics of the population and location**

The sample for this study consisted of my Year 8 class as allocated by the school. This class provided all the data throughout the duration of the study.

With all of these data sources, the process of cyclic reflection, as in an action research cycle, and synthesis of the collected data was the next consideration. Care had to be taken not to reduce the many perspectives into a single focus. A classroom should never reflect only one image or view. "In ethnographic research, the more perspectives represented, the stronger the research design, because each additional perspective contributes to a more complete picture of the scene of interest" (Eisenhart, 1988, p. 106). This study involved my immersion in the field. It occurred in the natural setting of a normal Year 8 mathematics classroom doing the same course as everyone else in Year 8 at our school. I encouraged the students to have a 'voice' and speak for themselves. Observations were global and did not focus on specifics. This proved to be an effective and appropriate methodology.

"Interviews and observations spaced out over long periods of time are an excellent
way of showing children's development and for the researcher they are an important source of knowledge about children's notions" (van den Brink, 1990, p. 38). A 'perfect' methodology is not a claim I can make, for despite all of the apparent worth of my data collection and analysis procedures, questions can still be posed. For example, "whatever the ethical guidelines adopted by a researcher, one question that must be considered is priority of loyalties and responsibilities" (LeCompte and Preissle, 1993, p. 109). In terms of this study my first loyalty has always been to my subjects (students) as they were also my main responsibility in my eyes and in the eyes of the school and of course, the students' parents. Students first, study second may have led to some compromises within my study or of its potential, but that serves as an indicator of the reality or naturalness of the setting. The 'naturalness' of my research rests within the action research model I adopted. My action research spiral involved posing my research question(s), engaging in some practice, measuring the learning environment, re-examining my research question(s) and then continuing through this cycle. The characteristic repetition and progression of action and reflection in several cycles of research, dubbed "iterativity, is the main source of rigour in action research" (Altichter, 1993, p. 49). My action research reflective methodological cycle occurred daily, as represented here in Figure 5.

![Figure 5 Daily cycle](image)

I also had weekly, monthly, termly, semesterly and specific events cycles. All of these contributed to the process of data reduction and synthesis in this study.

A conscious effort should be made to bracket any preconceived ideas concerning the correctness or otherwise of a particular research model. What matters is the extent to which the model is appropriate; appropriate to the skills of the teacher, the constraints of the classroom and the nature of the problem to be explored (Nixon, 1981, p. 7).

The individual teacher researcher addresses his or her research in a manner befitting the problem and does not fit the problem to a manner of research. This study may be unique and can never be replicated, but it can be duplicated in another setting by someone who would model their approach upon that which I have used. The important point here is that for this, my study, I have brought to bear all appropriate
techniques and utilised all available resources in the analysis of the data corpus. "Discovering or establishing units of analysis constitutes one of the primary tasks in processing ethnographic data. The ethnographer's challenge is to choose divisions that retain their natural integrity while providing sufficient focus for observation" (LeCompte and Preissle, 1993, p. 241). All such 'divisions', be they the categories used in my weekly or monthly reports retain their integrity and, I believe, provide sufficient focus for the observations I made. No doubt by the later stages of my study I was observing according to these categories as I had used them for so long I had learned them. This may be a limitation of the methodology I used in this study.

Data Collection

The methods of data collection used in this study operated in parallel with the data analysis phase of the research methodology. This study utilised a variety of data collection techniques. "Ethnographic methods used in data collection include participant observation, ethnographic interviewing, the search for artefacts and researcher introspection - reflecting on the research activities and context" (Eisenhart, 1988, p. 105). The function of data in action research is to provide a basis for reflection. "Data collection is not an end in itself, nor purely for hypothesis testing; rather, it is a means of documenting observations and thus mediating between the moments of action and reflection in the action research cycle" (Grundy and Kemmis, 1981, p. 330). This illustrates the approach used in my study where "data collection and analysis proceeded together throughout the period of the study" (Eisenhart, 1988, p. 107). Encompassed in the data analysis process is the procedure of data reduction. "Data reduction is not separate from analysis but rather part of it" (Miles and Huberman, 1984; Anderson and Burns, 1989, p. 201). "It is the process of selecting, focusing, simplifying, abstracting and transforming the 'raw' data into something capable of verification and possessing social meaning. 'Data reduction occurs continuously throughout the life of any qualitatively oriented project'" (Miles and Huberman, 1984, p. 21; Abbott-Chapman, 1993, p. 60-61). The primary data reduction in this study occurred in the weekly and monthly data analysis cycles. The first stage of data reduction involved the synthesis of observations, fieldnotes and audio recordings from each days lesson into a weekly summary. These weekly summaries were further reduced into monthly reports which included analysis of lessons recorded on video, independent observer reports and results from the learning environment surveys. Monthly reports were summarised into term reports which incorporated a methodological review and two term reports constituted a semester report. Weekly summaries form the main source of the data corpus. Observations, from whatever source, were divided into three categories (S, D and C):
• S category observations were those which seemed familiar, similar or the SAME as others previously recorded.

• D category observations were those which appeared DIFFERENT from previous observations.

• C category observations were neither S nor D and hence were more like COMMENT type observations pertaining to the classroom learning environment and its participants.

These categories were determined through the planning stages of the study taking into account the experiences of the practitioner and the recommendations of the literature. The categories survived the first month of the implementation and "remained functional throughout the study" (Howard, 1995, July). When raw data observations are reported in this thesis they are identified by a number, representing the week they were recorded during, and one of these categories; S, D or C. Thus a SAME category observation from Week 7 would have the prefix 7S.

The categories were applicable to each type of data source: observations, audio recordings, video recordings, independent observer reports, learning environment surveys and artefacts such as student class work, home work and assessments. "Field records collected through participant observation in the practical setting are one of the primary tools of narrative inquiry work" (Connelly and Clandinin, 1990, p. 5). As a teacher researcher my circumstances were unique. Even I would not, could not, duplicate the procedures I used in this study. "The best way for any fieldworker to keep fieldnotes is the way that best preserves that individual's observations and interpretation. Everyone's best way is different from everyone else's" (LeCompte and Preissle, 1993, p. 226). My approach was more than adequate for the circumstances. My fieldnotes or observations were enriched later that same day by reviewing audio recordings of the lesson. "Detailed fieldnotes should be written up by the end of the day in which the observations were made" (Gallagher, 1984, p. 6). Thus the rough 'in-the-field' notes were translated into more detailed fieldnotes and commentary. Things did not always go to plan however. On one or two occasions the audio recording was not successful (battery failure) and so on these days I was committed to a greater level of observation than might have otherwise been anticipated. Similarly on days when I was highly engaged in a participatory role the audio recordings were vital to the enrichment of the fieldnotes. "Any record is better than no record at all" (LeCompte and Preissle, 1993, p. 227). The use "of regular ethnography with microethnography" such as audio recordings is a "good technique" (Erickson, 1986). It is a very accessible means of gathering data. "The most accessible means of gathering data is audio-tape. The teacher is more able to interpret a tape than a stranger is, given an adequate degree of self-critical
awareness" (Stenhouse, 1975, p. 159). Nearly every lesson in my study was audio recorded and each recorded lesson was analysed by me (the teacher). "Write-up stimulates recall and enables the researcher to add information to that contained in the unelaborated raw notes" (Erickson, 1986). The recordings provide "a detailed, accurate account of the lesson frameworks - time spent and sequence of teaching / learning activities" (Good, Reys, Grouws and Mulryan, 1990, p. 57). One of my pre-implementation concerns related to the presence of the tape recorder and its impact on student behaviour. I wanted a natural setting for our classroom environment. "In making the tape recordings the novelty of the tape recorder eventually wore off and the children were behaving quite naturally" (Groarke, Ovens and Hargreaves, 1986, p. 82). This was also true of the class in my study. The tape recorder provoked occasional comment but was, in itself, not an issue.

In addition to audio recordings, a sequence of randomly selected lessons were video taped by a research colleague. I reviewed these video tapes as did my research colleague and we discussed my observations and commentary from each of these sessions.

When we listen to and look at social life closely, which is what a videotape enables us to do, we see and hear a different version of social life than is otherwise possible. We are able to examine more critically the factors which have played a dominant role in explanations of school performance (Mehan, 1993, p. 103).

I also utilised a second research colleague to conduct open-ended interviews with the students, addressing specific issues relating to the learning environment and which had emerged from the parallel analysis of the data corpus. In asking each student the same set of open-ended questions, ("standardised questioning" (LeCompte and Preissle, 1993, p. 169)), the independent observer accepted any response from the students. These responses were then summarised by me and discussed with the independent observer to ensure correct analysis before they were incorporated into the data corpus. Data from observations obtains support by asking the participants specific questions through interviews and survey sheets. "Schatzman and Strauss (1973) assert that the goal of qualitative interviews is the acquisition of data representing participant meanings" (LeCompte and Preissle, 1993, p. 171).

In addition to the independent observers interviews I obtained further knowledge from the students (the participants) through the use of survey sheets which often asked for further details of, or attempted to determine class consensus about, matters arising from the data corpus. "A further possibility is to gather perceptions of the classroom situation from the pupils" (Stenhouse, 1975, p. 159). This was done in my
study using a variety of instruments such as the My Class Inventory (Fraser and Fisher, 1983a) and the Constructivist Learning Environment Survey (Taylor and Fraser, 1991), additional written question sets and surveys, collections of class work and so on. Each of the techniques referred to above, such as the use of video, audiotapes, pupil input, collecting artefacts and the like, strengthen the triangulation of the data corpus.

The most important type of survey, conducted every month through this study, was the My Class Inventory learning environment survey. This will be discussed in detail in a following section. "Hamilton (1973) advises participant observers to recognise that research relations are facilitated if the observer can find some way to 'give' as well as 'take' " (Stenhouse, 1975, p. 156). The learning environment surveys are an example of 'give' in my study. The intrusion of the role of researcher on my teaching meant that there had to be some benefits to the students for participating in the implementation. The My Class Inventory survey and Constructivist Learning Environment Survey were attempts to enrich the study by way of improving the environment along the lines the students deemed most appropriate. The learning environment surveys were always discussed with the students who received individualised copies of the results. These discussions, along with other 'group process' discussions, constituted informant checking of the data, observations and conclusions I was collecting, making and drawing.

Results distributed to members, represented a stimulus for discussion, as many of the issues and questions described were drawn from ongoing discussions. They also represented a consolidation of discourse already transpired. These discussions were of great value in correcting misinformation and in refining my understanding (Wagner, 1993, p. 13).

It was vitally important in this study to obtain the students' perspective of how the environment was functioning and how it might be improved. "Interpretations are considered much more likely to be valid if they have been confirmed by participants" (Firestone and Dawson, 1988, p. 217). By returning many times to both the literature and the data I engaged in a search for patterns as I analysed the data corpus. The narratives that emerged from the data corpus attempt to give a complete, coherent and internally consistent, illuminating, plausible account of the dilemmas involved in establishing a collaborative, peer interactive classroom learning environment. In partnership with my reflections on the emerging data corpus were my reflections on the theoretical perspectives from which this study was formulated. "Procedures are seen to exhibit theoretical validity ('construct validity') if there is substantial evidence that the theoretical paradigm rightly corresponds to
observations" (Kirk and Miller, 1986, p. 22). If what I observe in the study matches the theoretical perspectives of my approach then I can lay claim to having theoretical validity.

Let us now examine the implementation development and the role of the student groupings in the study. As we have seen previously, external and internal reliability "do not lend themselves easily to replication in other settings or by other researchers" (Eisenhart, 1988, p. 108-109) in studies such as this. As the teacher researcher I have enhanced the replicability of this research "by carefully and thoroughly describing:

- my role in the study
- the theoretical and analytical constructs used to guide data collection and analysis
- the data collection and analysis procedures used" (Eisenhart, 1988, p. 108-109).

and I will now describe:

- "the choice and use of settings and people in the study" (Eisenhart, 1988, p. 108-109).

"Reasons for site selection or individual cases need to be carefully articulated and made explicit. There are no perfect designs" (Patton, 1987, p. 58).

Where resources limit the evaluation to the study of only a single site it makes strategic sense to pick the site that would yield the most information and have the greatest impact in the development of knowledge [or understanding]. In such a sample broad generalisations are not possible but logical generalisations may be (Patton, 1987, p. 55).

I chose my Year 8 class as the focus group for this study because it had the greatest potential to yield information and develop "knowledge" (answers to my research questions). A typical question for my study in this case could be "if the students like the environment and methods used in the intervention then the theory behind such techniques has merit and should be employed on a wider scale" (Patton, 1987, p. 55). This is also an example of a logical generalisation. As the teacher of the class being researched and as the researcher I to had several "insider" opportunities and "liberties" (Wagner, 1993, p. 11) which I was able to take advantage of – such as the collection of student records and the alteration of assessment practices for the study's benefit. At the same time I was subject to the school's administrative whim and our activities endured emergency drills, music rehearsals, and other timetabled and non-timetabled interruptions. Thus in my discussion of our classroom environment I do
not exclude the "other environments of our school and community" (Howard, 1995, July) which also affect us, the participants in our class.

"Issues of site entry and of research ethics are not really a problem to the in-class teacher researcher, as long as they are aware of such things" (Erickson, 1986). This is not completely true because one cannot carry out research without adhering to the prevalent ethical practices and codes even if you are researching your own class. An example of such codes is found in the American Psychological Association's publication *Ethical principles of psychologists and code of conduct* (American Psychological Association, 1992). This implementation deliberately altered the learning environment for the students and thus they and their parents had the right to be informed of the research plan and its expected impact. They had the right to participate (or not) without fear or favour regarding their placement and they retained the right to withdraw from the study, under the same conditions without fear or favour, at any point during the implementation. Of all who participated, no-one elected to withdraw.

Another issue relates to "developing a collaborative relationship with informants" and encouraging "group members to express concern when they perceive that the group is failing to function effectively" (Erickson, 1986). As will be seen in later narratives, the students were made aware of this requirement of group self-analysis, were regularly reminded of the need to monitor themselves and, in a couple of cases, they did report problems with group functioning and these were resolved. Selecting my Year 8 class also facilitated their acceptance of the 'goings-on' in the classroom, as far as the research was concerned, because they were new to high school and were prepared for 'anything'.

Initially, the pupils may have been puzzled at the comparative strangeness of some of the activities and suspicious of the teacher's motives. Gradually, however, they learnt that, by working in this way, they could have a greater say in what they did and in the way in which they did it (Jackson, 1981, p. 60).

Only after time and the sharing of experiences outside the classroom with others not involved in our work did the students begin to question our classroom practices. I do believe that I went a long way to "empathising" (Heshusius, 1994, p. 19) with the students in my study because I wanted so much to know how they felt about what they were involved in, which was, of course, my creation. The allocation of students to my class was made before the school year started by the school authorities with no consideration of the fact that the class was to be the subject of this research. Once 'in my class' I allocated the students to their groups within the class. "A teacher must
use professional judgement when establishing the groups. Children’s ability levels, personalities, leadership qualities, and verbal skills must all be taken into consideration" (Behounek et al., 1988, p. 11). Many factors were considered in the initial placement of students into groups in our class. "No class contained more than seven groups, thus making it possible to watch and report on all groups effectively" (Gayford, 1992, p. 43). In our class we had six groups thus enhancing the effectiveness of the teacher researcher observer. In this study we used groups made up of three or four students. Such arrangements seem the most favoured by research. "Careful consideration must be given to the size of cooperative learning groups. We used activities involving groups of three or four" (Behounek et al., 1988, p. 11). The groups to which the students were assigned remained in place until the end of second term. This thesis reports on the implementation for those two terms, or six months. Each of the two following terms had different grouping arrangements. Although the study continued through the third and fourth terms, this thesis does not report on those phases of the implementation.

**Summary to this point**

The preceding portion of Chapter 3 has endeavoured to explore the theoretical paradigms and research influences associated with the ethnographic action research methodology utilised by this study. We examined ethnography, its parameters of reliability, validity, triangulation and generalisability and the extent to which such concerns are applicable in this study. We examined action research which was the implementation model for this research and the theoretical premises behind the action research movement. In addition, we explored, to varying depths, several facets of the methodological procedures and data analysis practices employed in this research. Finally, we had a brief introduction to the development of the implementation and the structures functioning within the class being researched. Next we take a close look at the theoretical and practical underpinnings of learning environment research which provided this study with the principal quantitative measures of the success or otherwise of the implementation. Later in this chapter we will examine data relating to the students, focusing on the class as a unit, the groups as a unit and the individuals who make up these units, each of whom is different and contrasting. This will illustrate the variation and commonalities between the students and their range of experiences.
The role of Learning Environment research

Having founded my study on the multiple theoretical frameworks of Vygotskian perspectives, constructivism and socio-culturalism in mathematics education I required an implementation model and a measure of effect for this approach to my teaching and the consequent forms of student learning. As outlined in the previous section, I adopted an action research implementation model. Such a model facilitated the collection of the story of this implementation through the teacher-as-researcher ethnographic process. In addition to this wealth of qualitative data, learning environment measurement instruments were used to collect quantitative data which monitored the emerging effects within the developing classroom environment. "As a concept, a learning environment can be thought of as a variable experiential field whose contents are specified by its participants" (Steffe, 1991, p. 190). This was one of the primary concerns for my study. What did the participants think of their learning environment?

Thus the overall objective was to ensure close monitoring of the learning teaching environment. This would facilitate constant adjustment, within the theoretical parameters, to further develop the environment in accord with the students' preferences. A dynamic state of change existed within our classroom and this was controlled by both the students, as assessors, and the teacher, as facilitator. "The educative process is active in three ways. The student is active, the teacher is active and the milieu which they have constructed is also active" (Vygotsky, 1991, p. 89 in Davydov, 1995, p. 17). "The zone of proximal development is meaningful only if the environment is systematically taken into consideration. Environment is not merely the visible part that surrounds the individual; it is the whole culture with its constraints and benefits" (Oerter, 1992, p. 195). Therefore the learning environment cannot be ignored.

If "learning is constructive in nature and shifts the responsibility for knowledge construction from teacher to student", (Shavelson, 1992, p. 33), then it is only fair that the students' opinions of what best facilitates their learning be assessed, and that the environment be adjusted to accommodate their views. This also reflects a shift in responsibility with the teacher giving the students greater opportunity, and hence responsibility, to affect their learning environment. "The structure to support children's learning and participation evolves as children gain skills that allow them to assume increasing responsibility. This transfer of responsibility is jointly achieved by adults and children" (Rogoff, 1990, p. 86). As the teacher, I had the responsibility
of establishing the learning and teaching environment and then modifying it, moulding it, according to the students' preferences. "Teachers are constructors of learning environments through their efforts to modify or construct mathematical concepts" (Clement, 1991, p. 423). Such efforts effect a change on the learning environment, so in my study it was acknowledged and planned that this environment change would occur and then the change was monitored to see what the students' opinion was of the effectiveness of the new environment. Such monitoring is essential because "what makes teaching even more problematic is that the consequences depend on how learners perceive and construe them" (Sanders and McCutcheon, 1984).

Learning environment measures provide information about important aspects of classroom life. "It is important to consider the comfort of children's social relationships explicitly as children's social interactions are not always benevolent, even with a teacher and certainly not always with peers" (Rogoff, 1990, p. 202). "The school and classroom setting should be safe and conducive to effective learning" (CC, 1998, p. 36). Student feedback is important to the understanding of the classroom learning environment. We can make use of learning environment measures to monitor and guide attempts to improve or change the classroom learning environment.

On the basis of Fraser's (1986a, 1986b) reviews it can be concluded that it is possible for teachers to bring about substantial changes in the learning environment, making this learning environment more effective in promoting student outcomes. It is plausible that change of teacher behaviour is an important factor in these improvements of the learning environment. So it seems possible for teachers to influence student outcomes via the learning environment (Brekelmans, Wubbels and Creton, 1990, p. 347).

To emphasise the socio-cultural nature of the learning teaching situation we need to realise the importance of the cyclic processes which repeat over and over as the individual, student and teacher, and their environment develop. "The individual interacts with his environment, and in the process of interaction adapts to his surroundings. The surroundings are modified by this interplay between the individual and his environment" (Keeves, 1972, p. 29).

Learning environment measures are a practical attempt to improve classroom environments and my study is an example of a practical attempt to improve the classroom learning environment. "The learning environment analysis process consists of a five step cycle that is repeated until changes in classroom environment
reach desired levels. The five steps are: (i) Assessment, (ii) Feedback, (iii) Reflection and Discussion, (iv) Intervention and (v) Reassessment" (Fraser, Malone and Neale, 1989, p. 196-198). These steps describe the process I undertook in my study in an attempt to modify the environment towards that which the students would prefer. The emphasis is on the cyclic process encompassing reflection and intervention. Such work is not common and yet "in studies of person-environment fit, students were found to achieve better when there was a higher congruence between the actual classroom environment and that preferred by students" (Fraser and Fisher, 1983a, 1983b).

Although classroom environment has been an active area of investigation among educational researchers over the past 20 years, (although a surprisingly small proportion of this work was done in mathematics classes), relatively little research has been directed toward helping mathematics teachers assess and improve the environments of their own classrooms (Fraser, Malone and Neale, 1989, p. 191).

In the next section we will look at the instruments utilised for this purpose.

Using the My Class Inventory (MCI) learning environment survey

During months one, two, four and five of the study the students assessed our classroom learning environment using the My Class Inventory (MCI) (Fraser and Fisher, 1983a). "The MCI is well-suited for use at the lower secondary school levels. It measures five different dimensions. Satisfaction (S), Friction (F), Competitiveness (Cm), Difficulty (D), and Cohesiveness (Ch)" (Fraser, 1989, p. 2). The Satisfaction (S) scale measures student perceptions of the extent to which they and their peers enjoy the class and the work they do. The students are asked to comment for themselves and for others. The Friction (F) scale examines student perceptions of each other by asking about the levels of agreement and disagreement among the class members and how well they get along. The Difficulty (D) scale represents student perceptions about the difficulty of the classwork and the ability of themselves and others to do their subject work. The Cohesiveness (Ch) scale determines student perceptions about friendships between students in the class and the extent to which the students know each other. The Competitiveness (Cm) scale looks at the degree to which the students compete to finish first or are concerned about not keeping up with each other.
"In addition to a form which measures perceptions of the actual environment, the MCI has a form which measures the preferred environment" (Fraser, 1989, p. 2). The scales are the same with the questions or statements altered to ask the students what they would prefer the situation to be rather than what they perceive it to actually be. By comparing the actual scale to the preferred scale, I was able to make adjustments to the learning environment with the aim of enhancing learning and making the actual environment more like that which the students would prefer. "The directions for answering the two forms instruct students clearly as to whether they are rating what their class is actually like or what they would prefer it to be like" (Fraser, 1989, p. 3). Even with these directions I still had to reinforce the differences to the students when they completed the surveys, as they always completed both surveys at the same time. "Many teachers would prefer an assessment method which is economical in terms of the time required for administration. Consequently, a short version of several scales was developed" (Fraser and Fisher, 1983c). The attraction of the short forms is that they are economical in the time taken to administer and time taken to score, and consequently can be easily programmed into a lesson block. "The number of items in the short form is reduced to provide greater economy in testing and scoring time making it amenable to easy hand scoring" (Fraser, 1989, p. 2). "The short form of the MCI has satisfactory reliability for scales containing only five items each" (Fraser, 1989, p. 4).

Research issues associated with learning environment measures

The latest issue in the evolution of measures such as the MCI concerns something referred to as 'grain size'. This is the choice of level to which one applies the learning environment measure. A measure can be 'fine grained' and focus on a singularity or 'course grained' with a more 'global' focus. The MCI is 'fine grained' in that it focuses on one teacher and 'course grained' in that it focuses on the whole class. In this study it is also 'multi-grained' in that both of these foci and that of the student groups are examined. "Very often one study may pick more than one grain size" (Fraser, 1995, April). "Each MCI scale has satisfactory reliability for use with either the individual or the class as the unit of analysis" (Fraser and Fisher, 1983d, p. 12). "All scales have been carefully developed, extensively field tested among students, used widely in research and shown to be reliable" (Fraser and Fisher, 1983d, p. 2). The short form of the MCI has been used successfully in research by Fraser and Deer (1983).
Using the Constructivist Learning Environment Survey (CLES)

At the end of each school term, months three and six, the students completed the Constructivist Learning Environment Survey (CLES). The CLES is a learning environment instrument designed to "assist researchers to assess the degree to which a particular classroom's environment is consistent with a constructivist epistemology and to assist teachers to reflect on their epistemological assumptions and reshape their teaching practice" (Taylor and Fraser, 1991, p. 2). Such purposes were behind my use of the CLES, as constructivism was one of the paradigms framing my research and my philosophical position. The CLES version we used was comprised of four scales:

(i) autonomy
(ii) prior knowledge
(iii) negotiation and
(iv) student-centredness

"The Autonomy scale measures perceptions of the extent to which there are opportunities for students to exercise meaningful and deliberate control over their learning activities, and think independently of the teacher and of other students" (Taylor and Fraser, 1991, p. 2). Thinking independently was a strong focus within my study however certain 'control' aspects were less free. For example I allocated the students to their initial groups. The students had the autonomy to select their work partners within their group. This was everyone else on most occasions, or perhaps just one other at certain times. The students had the freedom to plan how they completed their mathematical activities but not necessarily the curriculum or the activities to do. Similarly they had little control, at the macro-level, of the timing of learning activities, but they did have such control at the micro-level (within their group). "The prior knowledge scale measures student perceptions of the extent to which the learning environment provides opportunities for students to meaningfully integrate their prior knowledge and experiences with their newly constructed knowledge" (Taylor and Fraser, 1991, p. 2). This particular aspect of learning was well facilitated within the context of our class operation. "The negotiation scale measures student perceptions of the extent to which the learning environment provides opportunities for students to interact, negotiate meaning and build consensus" (Taylor and Fraser, 1991, p. 2). This scale relates to the foundation of our classroom implementation, namely collaborative peer interaction. Social interaction, discourse, negotiating meaning and building consensus were all priorities within our classroom practice. "The student-centredness scale measures student perceptions of the extent to which the learning environment provides opportunities
for students to experience learning as a process of creating and resolving personally problematic experiences" (Taylor and Fraser, 1991, p. 2). Not as overt as prior knowledge or negotiation, student-centredness was evident and observed within our classroom as we developed the procedures and confidence to present our ideas while the ideas of others were discussed and analysed. "The CLES contains 28 items in both the perceived and preferred forms. Scales were found to display satisfactory internal consistency, discriminant validity and predictive validity" (Taylor and Fraser, 1991, p. 3). In this study the CLES served many purposes for, as Taylor and Fraser point out, it is a very flexible instrument.

It is important that researchers make use of the CLES to monitor students' views of their classes, investigate the impact that constructivist environments have on student outcomes, and to provide a basis for guiding systematic attempts to evaluate constructivist-oriented learning environments. Researchers could make use of the CLES in attempts to change teaching / learning styles to a more constructivist approach or in guiding teacher-as-researcher attempts to reflect on and improve classroom environments (Taylor and Fraser, 1991, p. 10).

This study attempted to make a practical application of the CLES as a measure of the implemented environment. The study gives importance to monitoring students' views, investigating the impact that a constructivist environment has on students, and evaluating our constructivist-oriented learning environments. The study also utilised the CLES to monitor the attempt to change my teaching / learning style to a more constructivist approach. It facilitated and guided my reflections on, and improvement to, the implemented classroom environment.

The influence of perceptions

By using these learning environment instruments I was able to monitor individual perceptions, group perceptions and class perceptions through the amalgamation of the data. "Within the classroom setting, teachers can receive feedback about their students' perceptions and implement changes in accordance with the findings" (Raviv, Raviv and Reisel, 1990, p. 143). Hence I was able to react to any one of the three perspectives of the environment.

"Teachers are able to become attuned to the mathematics classroom from the children's perspectives. When teachers view their own mathematics classroom from the children's perspectives can they respond more directly and positively to the children's needs" (Ellerton, 1989, p. 85). This was one of the aims of my research, to
see things from the students' perspectives, and hence I collected data from the
students as I tried to ascertain their views on the many facets of the environment as
implemented. By assessing the students' perceptions of their learning environment I
was informing myself of my students' knowledge and then acting upon this
information to "affect change from decisions as to the nature of the environment and
to enhance its effectiveness" (Lubinski, 1993, p. 201).

"The teacher is an important participant and observer of the educational process.
Furthermore, his or her perceptions determine to a large extent the learning and
social processes of the students" (Raviv et al., 1990, p. 143). My perceptions were
influenced, and possibly dictated to, by the perceptions of the students as returned to
me through the completion of the MCI and CLES surveys. The reality of the
situation was such that I made the most significant changes in relation to the overall
class data. "Giving students feedback on their cooperative behaviours and asking
them to reflect on how the group or class is behaving with respect to specific skills
can have good results" (Cohen, 1994, p. 26). Huber and Eppler (1990) provided
students with ratings of their own group members. "They were then asked to discuss
for five minutes what went wrong during the last session and how they could
improve cooperation next time" (Cohen, 1994, p. 27). As discussed earlier I
provided each student with individualised feedback of the MCI and CLES survey
data. Each received their own survey analysis plus that of their group and the overall
class results. These (group/class) were then discussed by the class. Occasionally,
reference was made to individual results in the discussions. I was then able to act on
making the perceived more like the preferred.

The parents' role

A further aspect in the study of developing an effective environment involved the
students' parents. While it may be true that "during the first year at secondary school
liking mathematics was associated more with classroom factors than with
circumstances, attitudes or practices of the home" (Keeves, 1972, p. 170), I believed
that parental influence was a factor worth examining within the context of what we,
our class, did in our lessons. I am not alone in these views.

Parental support and encouragement are vital to children's
mathematical development and success in school. Parents are their
children's first and most influential teachers. Many schools devise
programmes to help parents provide additional support in teaching
mathematics to their children. Such programmes are not dependent on
the background of parents in mathematics, but involve parents in
doing mathematics with their children. What parents do with their children counts more than anything else in fostering a positive attitude to and interest in mathematics. Parents assist teachers by making clear to their children the relevance and importance of mathematics to personal life and participation in society (Australian Association of Mathematics Teachers [AAMT], 1990, p. 29).

For this study, we held a parent's information evening where the parents engaged in a variety of mathematical activities which we had attempted or would soon attempt in class. This gave the parents a positive impression of the work their children would be doing in our class, and so they supported our work at school and the resulting positive attitude to mathematics extended into the home with their support of our homework activities. Such events highlight the important role that social and cultural influences have in shaping students' attitudes and interests.

Summary - Learning Environment research

With research supporting links between student perceptions of their environments and outcomes, as well as between the teacher's behaviour and the students' outcomes, I chose to make these facets fundamental to my study. This was achieved by having the teacher behave in such a way as to hopefully enhance or at least positively influence the students' outcomes and by using measures of the students' perceptions of the environment to indicate ways of improving the environment to benefit the students' outcomes.

A change in style

Three format and layout styles will be used from this point on. This study collected a wide range of raw data in the form of fieldnotes, both observed and audio recorded, video recordings, colleague observer interviews, written student surveys, learning environment surveys, photographs, tests and student artefacts. These constitute the observational data, the "particular description" (Erickson, 1986) in this study. As was shown on page 90, raw observational data is presented in Helvetica font like this sentence.

Where collected data has been analysed and synthesised and is presented as "vignettes" (Gallagher, 1984, p. 6) or "general descriptions" (Erickson, 1986) in a narrative form, it will be presented in Bookman font as shown by this sentence. The "interpretive commentary" (Erickson, 1986) or thesis report will continue to be presented in the normal Times font as shown by this sentence.
Next I will describe pre-implementation plans, actual implementation outcomes, the fieldnotes diary and daily workbook recording process, the process of synthesising daily fieldnotes to a weekly synopsis and subsequently into a monthly review, our Year 8 mathematics course outline, general course notes, course assessment guidelines, notes presenting the implementation to the students and parents and finally the determination of the student groupings.

Pre-implementation notes

In preparing myself, the students (into groups) and the physical classroom environment for the implementation, I made notes on several key areas which I had gleaned from the literature as needing pre-implementation organisation. Part of the success (or otherwise) of this implementation related to how well the environment was established prior to the first lesson. I felt it was vital for the students to gain the impression that what they were entering into was in fact quite the norm for first year high school mathematics classes. Important to the creation of this impression was the appearance of my role as the teacher researcher. I had to be confident and sure so to achieve this I prepared several summaries of points from the key areas identified in the literature. The summaries, or teacher's notes, are presented below along with reports reflecting the actual outcomes of these implementation plans.

(a) Characteristics to develop in a collaborative peer interactive environment:
- a collaborative learning classroom must foster autonomy and effective learning by establishing and developing appropriate social norms just as in the family or community situation.
- train the students in the basic interpersonal and small-group skills needed for effective collaboration.
- use students various cultural backgrounds as a focus for discussion; that is use their experience / use their prior knowledge / use their previous experiences to determine their attitudes.
- must value and respect what the student knows because doing so enhances the student's self esteem / worth.
- encourage the students use of language, orally and in writing.
- provide opportunities for students to exchange ideas and develop their ability to communicate and reason.
- listen to student's ideas and encouraging them to listen to one another to develop mutual respect.
- teach the students to ask relevant questions, give coherent explanations, challenge each
  other's thinking, provide effective leadership, resolve conflicts between ideas and
  conclusions, and seek to understand each other's reasoning and perspectives.
- discussion, oral work must be emphasised and it must focus on / around the students.
- try to diffuse the idea that maths is a 'content experts' subject and retain the primary
  school ethos that 'we are all in this together'.

Social norms were a focus in the earlier stages of the implementation as was the
development of collaborative skills. However, the overt presence of these
diminished as time passed. There were instances of the class addressing such norms
during the implementation and this evidence suggests that work on developing
effective social norms was never complete. Occasional reminders were required.
Establishing students' self esteem and valuing their background and experiences
were constant priorities throughout this implementation. They were not dealt with in
isolation, but rather developed along with the mathematics content covered in each
lesson. Ethnicity was not a factor in our classroom as only one student was from a
fundamentally different ethnic group to the rest of the class, however cultural
experiences, based on each student's background, were utilised. Developing skills of
listening, to the students for the teacher, and to each other for the students, effective
discussion skills and effective collaboration skills within the class, were also
constant priorities during the implementation.

(b) The groups:
- three, four or five members.
- initially be heterogeneous both academically and in terms of their social characteristics.
- teacher selected using any available academic and social measures.
  Term 1: Teacher-selected groupings. Term 2: Student-selected groupings.
- work on only one topic at a time.
- encourage the students to work to ensure that every group member learns and discusses
  the material being learned.
- structured the groups so that the students;
  (i) perceive that they 'sink or swim together' (positive independence),
  (ii) work to ensure that every group member learns (individual accountability),
  (iii) discuss the material being learned face to face.
- ensure that the class is at ease with the presence of tape recorders - avoid anyone being
  self-conscious.
- consider alternative grouping techniques;
e.g. Jigsaw: 5 groups of 5 then all the number 1’s from each group regroup, either mid-
session or once 'expert' status achieved, to form a group of 1's each of whom is an 'expert'
in their 'field' or question.

eg. Envoy: another example of regrouping techniques where each group sends one
'ambassador' to some other group to share in their work.

Upon commencement we had groups of 3 or 4, which were acceptable parameters
according to the literature, and these groups remained teacher-selected for one
semester (two terms), not one term. Mathematical ability groupings were utilised at
the start of Term 3 and student-selected groups were used in Term 4. Terms 3 and 4
are not the subject of this thesis. The alternative grouping techniques, Jigsaw and
Envoy, were never utilised. The remainder of the teacher's notes presented in the
passage above survived through the implementation.

(c) Teacher traits to develop:

- group work should not dominate the environment (it is not effective in achieving all
  mathematical goals).
- vary the teaching style - facilitate learning, don't just teach!
- watch the students learn and discover on their own.
- suspend judgement of student ideas, entertain their suggestions.
- help students evaluate one another’s suggestions while critically reflecting on them.
- encourage students to guess courageously.
- never presenting a solution as the only one nor answer the students' questions, but rather
  support, suggest, direct and guide the students.
- to enhance understanding expose the students to a variety of representations of a concept
  for example writing, calculation, modelling, drawing, talking, listening, and so on.
- show the students that their conception may have limitations and that there may be
  situations where their conception does not work.
- in reminding a child to take a step that is understood we encourage the shift from other
  regulation to self regulation which is a goal of collaborative learning.
- challenge the students to go beyond their current thinking, continually increasing their
  capacities.
- skills should be taught within a context - maths tends to be de-contextualised.
- maths may be valued more if it services a student need arising within context.
- aim to highlight mathematics / society links.
- attempt to diminish the teacher expertise factor.
- role change is important - teacher becomes student - student becomes teacher.
- tailor the mathematics to the students' abilities acknowledging their backgrounds /
experiences.
- teachers must develop learning experiences appropriate for the particular students in particular schools.
- reflect, analyse and be critical of my own practice!

While my teaching style did vary through the implementation, group work did dominate in our environment. Often however, group work is merely physical location and within this the students worked individually, together in their groups and, at times, in the broader class setting. In order to stand back and watch the students I had to overcome my desire to step in and help them. This was often difficult to do. As the observations in Chapter 4 will show I was very successful at entertaining the students' ideas, sometimes to their frustration as I entertained the incorrect as well as the correct! Never presenting a solution as the only solution, and guiding the students rather than directing them, proved to be skills which I constantly endeavoured to exhibit. These behaviours (or lack of them) had quite an effect on our learning teaching environment. Similarly important was the teacher-student role reversal process. Nearly all of the other points in the passage of teacher's notes above remained paramount throughout the implementation. Many will be seen in our analysis of the observations in Chapter 4. Points from the passage of teacher's notes above which did not remain influential in the implementation include: contextualising skills and mathematics content, and developing specialist learning experiences. These arose as the curriculum provided, however I did not make a deliberate effort to facilitate these matters.

(d) Assessment techniques:
- reward groups for doing well as a group and make the group's success depend on the individual learning of each group member. For example:

(i) when a group member presents a correct solution, the group gets extra marks (≈10%) added to the assessment for that piece of work,

(ii) each group member gets the same mark for the written work submitted by the group,

(iii) every time the group's average improves each member of the group gets extra marks (≈10%) added to their results,

(iv) when an individual's average improves, each member of the group gets extra marks (≈10%) added to their results.

- assess the groups by teacher observation as well.

All of these points were tried and remained in place during the implementation. Tables of assessments are presented throughout Chapter 4.
(e) Data collection methods:
- personal fieldnotes which describe each day's plans, actions and responses, and record observations of the participants and other significant events.
- audio recordings of the class discussions to monitor and track daily events.
- audio recordings of informal conversations between teacher and student(s) to facilitate 'zone' mapping.
- audio recordings of interviews of at least one student per topic to ascertain how well it went.
- surveys and questionnaires of the student's attitudes and perceptions of their classroom environment.
- the search for artefacts or review documents especially student material which will build into a portfolio.
- researcher introspection, a form of self-monitoring involving the keeping of a diary to record regular reflections in and maintain focus by referring to the original issue.
- monitor the role of group processes outside the classroom.
- after observations the second stage of data recording takes place and involves the preparation of detailed fieldnotes written in narrative form.

The main omission from the implementation of the points listed in the passage above was the recording of informal conversations between teacher and student(s). This was tried from the beginning of the implementation, but after only a few lessons it was quite clear that this data source was both ineffective, in that it was not yielding any data beyond that which simple observations and fieldnotes were yielding, and inhibiting, to my critical role of teacher. Teaching took priority, as it must. Similarly, I was able to utilise the writing of topic summaries by the students as a more efficient way of reviewing topics than the interviewing of a student or two.

The remainder of the teacher's notes presented in the passage above represent some of the data collection techniques which were utilised throughout the duration of the study.

(f) What to focus on (as an observer):
- form, quality and effects of teaching and learning in this environment.
- try to see the classroom activities from the students' point of view in order to understand the effects on the learning environment.

These points remained valid throughout the study and were frequently refreshed by being referred to when each week's summary of fieldnotes, observations and specific events was compiled.
(g) Learning environment assessment tools:
- administer the My Class Inventory [MCI, short form] instrument, once every four weeks or so, to measure and monitor the students' perceptions of the actual classroom environment and their preferred classroom environment.
- administer the Constructivist Learning Environment Survey [CLES] instrument, once a school term, to supplement and enrich the data from the MCI surveys.
- students' dispositions can be supplemented through informal observations as they participate in class discussions, attempt to solve problems, and work on various assignments individually or in groups.

These measures formed the principal source of quantitative data for this study. The frequency of surveying as predicted in the passage of plans presented above proved achievable and was maintained for the duration of this study.

(h) Questions to ask the students:
- What do you like doing in maths?
- Who do you know who would use mathematics and for what task?
- Who would you / do you go to for help? (each other or teacher)
  - this reflects on the success of the implementation which aims to create a collection of learners, not students and teachers.
- In doing activities -
  - did you like it? why did you like it? where did it come from?
  - how could you code it? how would you share it?
  - that is, what makes for a successful activity?
- request reactions to working analyses or processed material from selected informants...

Not all of these questions were asked however several others along with some of these were posed via the written questionnaires the students completed from time to time or via the interviews conducted by a colleague observer. The student responses are presented at the appropriate points in the observations reported in Chapter 4.

(i) Analysis and Review:
- make a careful and thorough description of the settings and people involved, the social conditions under which the study takes place, the role and status of the teacher researcher in the study, the theoretical and analytical constructs used to guide data collection or analysis and the procedures used in collecting and analysing the data corpus. Doing so will make the study replicable.
- this information should be presented so that other researchers are able to undertake similar studies to determine whether similar findings emerge elsewhere, whether the same findings are validated elsewhere, or whether the same findings emerge for someone else analysing the original corpus of data.

- of concern is the possibility of drawing erroneous conclusions from spurious relationships in the data. This necessitates a careful search for alternative or disconfirming evidence and the elimination of rival or alternative explanations, both in doing the research itself and in presenting the findings.

- problems of external validity are reduced as obstacles to comparability across groups are overcome. Here again, a careful description of settings and people, the conditions of study, and the constructs used give other researchers the information necessary to assess the typicality of a situation and thus the appropriate comparison groups and translation issues.

Many of these points are exactly what I am doing here in this section or have already detailed in the earlier presentation of what the literature says on these matters. A critical point, which requires constant awareness in a study such as this, is that the researcher must be on the lookout for alternative or disconfirming evidence throughout the study. I was constantly reminding myself of this need and actively sought such evidence as the observations in Chapter 4 will show.

Another item from the pre-implementation and implementation stages of this study which we can describe here is my fieldnotes and observations diary. This was a calendar year diary with a day to an A4 page. Into the January (before the school year) section of the diary I posted most of the pre-implementation stage material. This included my timetable, shown in Table 22 in Appendix 1, and titled 'The teacher’s (my) timetable’, the set of the teacher’s notes we discussed previously, some classroom activity ideas suitable for use in developing collaboration skills and the ‘Year 8 Mathematics with Mr. Ireland’ document which we will discuss shortly.

From February 3 onwards, the fieldnotes and observations dairy consisted of the fieldnotes and observations for each day’s lesson Monday to Friday. The weekend page (Saturday/Sunday), on the left hand side of the page opening, contained reflections of the past week, particular comments and notes or points on mathematics content to follow up in the coming week – on the Monday, which was the facing page on the right hand side of the page opening. Thus the start of a new week was always informed by the important developments from the previous week. The term breaks (usually two weeks) were sections of the diary which were utilised to reflect on the past term particularly examining the methodology for the study. It also
contained task lists and facets of the research design or theoretical background which were to be investigated further. At the rear of the diary was a listing of the students and their collaborative groups for Semester 1 (Terms 1 and 2), and for Terms 3 and 4. There was also a year long, day by day planning chart which listed the curriculum lesson sequence, topic by topic, along with the schedule of tests and research events such as video lessons, interviews and learning environment surveys. The Year 8 (first year of high school) mathematics course which we studied (Claffey, 1992), consisted of the topics shown in Table 23 in Appendix 1, titled 'The Year 8 mathematics course'.

In addition to our subject-based lessons we had a further 20 or so lessons assigned to various purposes, such as introduction to the course, revision, tests, mathematics week activities and exams. We also had long weekends, sports carnivals and arts festivals occur throughout the normal school year. Incorporated into this year long Year 8 programme were 11 lessons in which we administered the learning environment surveys, 9 lessons where we made video recordings, 8 lessons which included colleague observations and interviews of the students, 1 lesson in which we had a photographic session and numerous lessons where we were visited and observed by research colleagues and interested school staff. Along with the fieldnotes, observations, learning environment surveys, colleague observer interviews, various questionnaires and surveys, we generated over 120 hours of audio recordings and over 6 hours of video recordings for our data corpus.

In addition to the diary of fieldnotes and observations and the appropriate texts (Claffey, 1992) I maintained a daily workbook which outlined the lessons for my five classes each day. This document principally outlined the mathematical content for each lesson along with any appropriate pedagogic notes. It also contained all the assessment records for my classes. Many lesson notes for the study class included reminders about the implementation or highlighted key questions which were to be addressed during the lesson that day. Key questions to the study were maintained on a 'page marker' sheet which remained inserted in the current day page of the fieldnotes and observations diary. These key questions are shown overleaf in Figure 6.
1. Are the students working collaboratively?

2. Are the students working beyond their own knowledge base?
   For example are they explaining to each other?, asking for help
   from each other?, sharing out the workload? Do they admit they
   knew this idea before or do they admit they are 'learning'?

3. What are the students' attitudes to:
   (i) the class?
   (ii) the group?
   (iii) the subject?
   (iv) the teacher?

4. Peer interaction - how much chat is just discussion compared to how
   much is teaching / helping others?

5. Any other observations?

Figure 6

Key questions reminder page marker

These questions changed little over the course of the study for as focus questions
they were meant to endure the complete implementation. Question 1 came and went
once the groups had settled together.

A key facet of the pre-implementation phase of a study such as this was that it did
not stop once the implementation began. As a part of the action research cycle of
reflection, pre-implementation plans were re-visited and continued to influence the
implementation, even several months down the track. An example of this was the
emergence of the monthly report as the most critical piece of the data analysis
process. The method I utilised in synthesising and analysing the daily fieldnotes and
observations were outlined earlier in this chapter (see Data Collection). Once daily
narratives were completed, they were then analysed into weekly summaries which
were further synthesised into monthly reports which were then summarised into term
reports and finally semester reports. Over-reducing raw or analysed data can
produce a scenario which reflects little of that seen in daily observations, and I found
that the critical point in this study for the focus of the data emerged to be the monthly
reports.
Table 1 below shows the key focus areas identified in each month's report.

Table 1  
**Key focus areas in monthly reports.**

<table>
<thead>
<tr>
<th>Month 1</th>
<th>Month 2</th>
<th>Month 3</th>
<th>Month 4</th>
<th>Month 5</th>
<th>Month 6+</th>
</tr>
</thead>
<tbody>
<tr>
<td>The student document or first principles</td>
<td>The student document</td>
<td>-</td>
<td>The student document or first principles</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Marks for groups</td>
<td>Assessment</td>
<td>Assessment</td>
<td>Marks / Assessment</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Work ethic / process</td>
<td>Group work</td>
<td>Group work</td>
<td>Group work process / ethic (students)</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>The environment - group size and effect</td>
<td>The environment</td>
<td>The environment</td>
<td>The environment - group size and effect, layout, and so on.</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Student support and criticism of each other and the teacher</td>
<td>Support / criticism</td>
<td>Support / criticism</td>
<td>Support / criticism of each other</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Student listening skills</td>
<td>-</td>
<td>Listening skills</td>
<td>Students listening skills</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Teacher is focus - questioning skills of students</td>
<td>Questioning - group versus teacher</td>
<td>Questioning - group versus teacher</td>
<td>Questioning - group versus teacher - teacher focus</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Teacher use of student features</td>
<td>Teacher comments and observations</td>
<td>Teacher comments and observations</td>
<td>Teacher use of students (features) comments and observations</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Tape recorder</td>
<td>Tape recorder</td>
<td>Tape recorder / video recorder</td>
<td>Tape / video</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Other practical applications</td>
<td>X</td>
<td>✓</td>
</tr>
</tbody>
</table>

Month 1 contains a more detailed comment on each key focus area and Table 1 shows how these evolved during the early months of this study. By the fourth month the process of data synthesis had stabilised to the key focus areas shown. After the first six months, reported in this thesis, the model stabilised and was retained for the remainder of the year (not reported in this thesis). By maintaining this data synthesis model a comparative base was formed between data from this study and subsequent analyses of the data to be obtained in Terms 3 and 4. The third key focus area,
'group work process or ethic (students)', was the most significant and was further detailed under the following sections:

(i) discussion, (ii) discussion/explanation, (iii) explanation,
(iv) background, (v) tasks, (vi) noise, (vii) behaviour, (viii) help,
(ix) homework, (x) observation, (xi) special sections.

Thus the monthly reports collected observations which were categorised under the key focus areas listed above in Table 1. Data falling within the third key focus area was consequently further analysed to see which of these additional criteria best described the observation.

Another 'key' focus area included the expectations of the school for students and teachers of Year 8 mathematics, shown in Figure 20 in Appendix 1, and titled 'Year 8 - General Mathematics Notes'. Such points were explained to the students during the first lesson and became a 'matter of record' after that. Most of the points highlight matters of organisation and administration for the students and their teachers. Not all teachers follow such guidelines 'religiously' and hence not all students develop mental or journal writing skills to the same degree. A second document, shown in Figure 21 in Appendix 1, and titled 'Learning Mathematics', highlights the underlying approach to mathematics learning and teaching within the school. This document was explained to the students and their parents at the Year 8 Parents' Mathematics Night. Both of these school-based documents fitted into the underlying approach taken by my implementation. Coupled with these general notes, and interplaying much more significantly on my study, are the assessment guidelines for all Year 8 mathematics classes, shown in Table 24 in Appendix 1, titled 'Year 8 Assessment'. With the exception of the three end of term tests and the final exam, all of the assessment items were class-based and were set by each class teacher individually. Professional common sense (survival) meant that several of these tasks were shared by teachers and hence common to several classes. As discussed earlier, for the class in this study, this assessment programme had many additional items such as the monthly learning environment surveys.

The next pre-implementation document consisted of several parts and was the document I provided to the students in the class involved in this study. The document is reproduced in its parts as Figures 22 through 26 in Appendix 1.

The first four paragraphs, presented in Figure 22 in Appendix 1, and titled 'Year 8 Mathematics with Mr. Ireland', set the tone for high school mathematics and particularly for our collaborative peer interactive classroom learning environment. The important points emphasised to the students were that they had already been doing
mathematics for a long time and that learning mathematics, while a complex process, does not only belong to the so called 'experts', especially when we work together. One of the most common causes of "unproductive anxiety about school mathematics", evident "even among students who achieve well" is that "to do mathematics you have to have a mathematical mind" (CC, 1998, p. 209). Working together, in groups, made us a powerful learning and teaching force capable of handling the complexities of this subject. However, we were also responsible for our own learning, and working together helped us to meet this responsibility. Discussion was a key element to our collaborative processes and when we valued and respected each other's work we all benefited greatly.

The section presented in Figure 23 in Appendix 1, titled 'How does it work?', describes many of the functions of collaborative groups and outlines several points which impact on the individuals who make up such groups. The concepts of group design, Director, Producer, and so on, were never pursued in the implementation. The set of 'teacher values' were provided to further focus the students attention on successful group practices. All of this gave us a basis upon which we could establish the norms of collaborative practice and the norms of social arrangements and behaviour for group work.

The section presented in Figure 24 in Appendix 1, titled 'How are you assessed and graded?', outlines the assessment processes emphasising group facets in preference to individual facets. Several of the methods of rewarding effective group work suggested by the literature were incorporated into our assessment calculations. As will be seen through the observations in Chapter 4, individual facets of the assessment process overshadowed the group-based assessments. Some measures were taken to re-dress this during late Term 2 and through Semester 2.

The types of assessments we utilised are described in Figure 25 in Appendix 1, titled 'Types of assessment'. This did not dominate our classroom practices but for an early document it did provide the students with some necessary guidance as to how they were expected to record their work and their progress and the many means by which they could communicate mathematically. For several of the students this was a revelation, for in the past they had only thought of mathematics in terms of right or wrong answers.

One further section, presented in Figure 26 in Appendix 1, and titled 'Perceptions', highlights the important focus the study had on monitoring the learning environment in order to develop an effective collaborative peer interactive classroom learning
environment. Effective for each individual, each group and all of us as a class. The measure of our effectiveness would be our perceptions of our learning environment. These would be monitored regularly and the results would be used to feedback to ourselves how we can further improve our environment for learning.

One final statement summed up my desires.

YOUR OPINION IS THE MOST IMPORTANT FACTOR. PLEASE GIVE IT FREELY AND ENJOY YOUR MATHEMATICS.

I wanted the students to feel free to raise their voice to any issue, for an important aspect of being empowered to improve one's learning environment is knowing that you have a say in the direction that improvement should take. So, who are we? Let us now examine the group formation process which brought the students together.

Determining the student groupings.

This next section comes from the pre-implementation phase of the study.

Determining the student groupings - Term 1

The names of the students in my mathematics class were obtained one week prior to the commencement of the school year. I had been allocated Group 5 in Year 8 mathematics and this consisted of 23 students.

I then requested information about the abilities of these students from one of the school's counselling staff. They advised me that the Year 8 students had been ranked on the basis of two assessments. These assessments were a piece of creative writing and a comprehension test. The assessments had been administered by the English subject teachers at our school. The students had then been divided into two streams with three classes in each stream. The top class in each stream contained the most able English subject students, based on the two assessments, while the other two classes in each stream were an equal mix of the remaining students. I was also informed that the Social Studies and Mathematics classes would be the same as these English classes. My Group 5 students were one of the mixed ability (no top English subject) students.
From the students' records I collected the following data about the students in my class:

(i) which primary school they attended,
(ii) a mathematics rating out of either 3 or 4 depending on the system used by their primary school (1 is high ability) and which was checked against the primary school report comments,
(iii) a writing rating determined from primary school report comments or rated as for mathematics above,
(iv) a reading rating determined from primary school report comments or rated as for mathematics above,
(v) an indication of their ability to operate effectively in a group work situation based on the comments in their primary school reports,
(vi) an indication of their maturity level based on the comments in their primary school reports,
(vii) a general ability rating, which the counsellors had determined on the basis of a variety of tests, including IQ, and interviews and background information from the primary schools and
(viii) any other comments from their primary school reports or their enrolment interview records which I considered of value in determining the social or academic characteristics of the child. Some examples include: may need special education support, parents especially request more mathematics homework, tutored in mathematics, easily distracted, very quiet, still developing language skills.

This raw data was entered onto a database shown in Table 25 in Appendix 1, titled 'Raw student data'.

On the basis of this information I assigned a numerical value to each category as follows: 1 to 3 (1 high) for ability in reading, writing and mathematics; -1, 0 or 1 for ability to work in groups and maturity level (-1 = an individual or immature, 1 = group worker or mature, 0 = unsure or no data); and -2 to 1 for overall ability (-2 = learning difficulties, -1 = below average, 0 = average and 1 = above average). I also assigned a numerical value to the previous school information, namely 0 = unknown, 1 = primary school on the same campus as the
high school in this study, 2 = city school and 3 = country school. Each student was assigned a number and this 'coded' data was entered onto a second database, shown in Table 26 in Appendix 1, titled 'Coded student data'. Names were not put on this data base. Next each of the six 'numerical' categories was ranked separately which resulted in a listing of the student numbers from the most able to the least able and another database was created to contain the six ranked sets of data shown in Table 27 in Appendix 1, titled Ranked student data'. A further column linked the 'numerical' data of the source school to the student numbers.

On the basis of the mathematics ranking the students were assigned to one of six groups from the most able student first to the least able student last. This assignment occurred in the following group order: 1, 2, 3, 4, 5, 6, 6, 5, 4, 3, 2, 1, 1, 2, and so on. All groups had four students assigned to it except group 1 which only had three. This grouping structure ensured that none of the first, second, third or fourth sets of six students, ranked according to their mathematical ability, contained anyone else from the same set. Thus the six most able students, ranked by mathematics ability, were all put into different groups and so on down to the last five least mathematically able students. The structure was now tested to see if any clashes across groups existed for the other five categories. It was decided that any group with two or more clashes in any category would have to be altered by exchanging a student, or two, with another group. The first three categories, mathematics, writing and reading, produced no such clashes. The fourth category of group worker versus individual produced a triple clash in group 4. Once this was sorted out the fifth category, maturity, also worked but the sixth category, overall ability produced two triple clashes in groups 4 and 5 and a double clash in group 6. This took some considerable sorting out. After trying approximately sixteen or so combinations it seemed that I had one that worked. Then it had to be tested for the final category, previous school. The aim was to ensure the widest possible range of social backgrounds existed within each group. That is, no one group consisting of all local students or city students or country students and so on. This produced two triple clashes in groups 2 and 5 which were eventually worked out. The final structure had one group, group 4, with a double clash in the maturity category. This
was accepted as the clash was in the middle of the ranking and was considered to be non-threatening to the group.

By the end of the first three days of schooling two students had been withdrawn from the class reducing the numbers from 23 to 21. Fortunately this reduced two groups of four students each to groups of three students each and for the start of the second week the class consisted of three groups with four students each (groups 3, 4 and 6) and three groups with three students each (groups 1, 2 and 5). One of the withdrawn students never actually joined the class and the other was only present on Day 2 before transferring to another school so the impact of these movements was negligible.

The final outcome appears as illustrated in Table 2 below.

Table 2

Final student groupings.

<table>
<thead>
<tr>
<th>Group</th>
<th>G 1</th>
<th>G 2</th>
<th>G 3</th>
<th>G 4</th>
<th>G 5</th>
<th>G 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student</td>
<td>14</td>
<td>8</td>
<td>11</td>
<td>20</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Number</td>
<td>19</td>
<td>21</td>
<td>23</td>
<td>15</td>
<td>7</td>
<td>16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>Maths</th>
<th>Writing</th>
<th>Reading</th>
<th>Groups</th>
<th>T = maturity</th>
<th>Ability overall</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>WHERE FROM</th>
<th>Local College (9)</th>
<th>City (7)</th>
<th>Country (5)</th>
<th>Other (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
</tbody>
</table>


The first four rows list the student numbers as allocated to the six groups, indicated as columns G1 to G6. Students number 1 and 13 did not start the term in our class and hence are shown as ± and †3 above. Within each column or group is a value or symbol which indicates the level of clash for the six categories used to determine the groups. A 0 (zero) indicates no clash, a √ indicates one clash and √√ indicates two clashes which, as mentioned before, only occurred in the maturity (T) category for Group 4. The final four rows indicate the previous school location data for the students in each group. One further guide to these placements arose when our learning support teacher offered data relating to her assessment of these students based on a series of ability measures where A represents the most able and D represents the least able. These are shown in Table 3 below.

Table 3
Additional student data.

<table>
<thead>
<tr>
<th>Group 1</th>
<th>Group 2</th>
<th>Group 3</th>
<th>Group 4</th>
<th>Group 5</th>
<th>Group 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>B</td>
<td>A</td>
<td>C</td>
<td>A</td>
<td>*</td>
</tr>
<tr>
<td>B</td>
<td>C</td>
<td>*</td>
<td>B</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>C</td>
<td>A</td>
<td>B</td>
<td>B</td>
<td>*</td>
<td>A</td>
</tr>
<tr>
<td>-</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>B</td>
<td>A</td>
</tr>
</tbody>
</table>

* data unavailable

This information arose after the groups were determined. The learning support teacher and I examined the groups based on her additional data and concluded that the abilities for each group were quite well balanced and supported my allocation of the students to these groupings. Her only observation was that while Group 6 appeared strong her information also alluded to 'other' problems that some of those students had which would equalise any apparent advantage. I would wait and see. If these groupings were dysfunctional I could change them. Thus by examining the wide range of socio-cultural, academic and background data of the students I had the students placed in their groups so as to "balance the composition of each group" with regard to these known data (Webb, 1991, p. 379). The names of the students in each group are shown overleaf in Table 4:
Table 4
The students and their groups.

Group 1  Betty  Group 4  Mary
  Jenny
  Cathy

Group 2  Emma
  Denise
  Amanda

Group 3  Hillary
  Gwen
  Faye
  Isobel

Group 5  Group 6  Robyn
          Narissa
          Penny

          Stacey
          Trudy
          Wendy
          Vicky

Thus the implementation is planned, the students are allocated to their "balanced" groups and all is in readiness to commence.

Chapter Summary

This chapter has examined the methodology for this study and described the planning and development of the classroom intervention. In discussing the methodology I looked at the nature of qualitative research and how ethnography informed the process by which this study was carried out. I considered the role of quantitative analysis in this study and detailed aspects of reliability, validity and triangulation noting how these emerged from this study's design. I also presented the role of action research and the teacher-as-researcher model which formed the basis for research action in this study. I identified the myriad of data sources the study used, along with the characteristics of the population involved and the location of the study. Data collection procedures have been outlined with a specific analysis of the role of learning environment surveys and related research being given. Next, this chapter began the process of presenting the data, with a progression through the pre-implemention phase of the study. I looked at the written preliminaries for teachers and students at the school and for those specifically engaged in this study. The basic social and collaborative norms upon which the study builds were presented as were aspects of classroom procedure, curriculum content and assessment practices.
Details of the use of data collection devices such as my fieldnotes, or observations diary, and other day to day classroom and research equipment were highlighted along with the teacher's timetable, daily work book, course outline and sequencing, and the process of reducing and analysing aspects of the data. Finally, I examined the method used to group the students prior to implementation.

Now everything is in place. Next the reader can live first term with the students and their teacher (me) and take the journey that led to the development of our collaborative peer interactive classroom learning environment. Chapter 4 will present the narrative for the data collected during the first term, ten weeks, of the study as well as highlights from the data collected during the second term, weeks eleven to twenty one, of the study. During this time the students remained in their initial groupings. For Term 3 the students were placed in mixed groups based on mathematics ability and for Term 4 the students self-selected 'friendship' groups. Most of the data for Term 2 and all of the data for Terms 3 and 4 is not reported in this thesis due to restrictions on thesis size.

Let the story unfold...
CHAPTER 4

DATA NARRATIVE

Introduction

In previous chapters I have presented the literature pertinent to this study from the fields of mathematics education, collaborative group work, Vygotskian developmental theory, constructivist pedagogy and learning environment research. These fields formed the multiple theoretical perspectives which framed this study. Also presented was the methodological design for the study involving an ethnographic perspective which had a teacher-as-researcher focus. This chapter contains the narrative for the observational data collected during the first term (three months or ten weeks) of this implementation along with highlights from the narrative for the observational data collected during the second term (three months or eleven weeks) of this implementation.

The data for this study, constituted of observations, reports and results, is analysed and interpreted in this chapter. The data sources included: daily fieldnotes; daily audio recordings of lessons; MCI and CLES learning environment surveys; video recordings of selected lessons; independent observer reports on selected lessons; results from Mid-Term, End of Term and special group-worked tests; Buddy reports; group work in other subjects reports and photographs.

The sections in Chapter 4 start with Month 1 which details the Term 1 programme and the narrative for the observational data and the data from specific events that arose during the month. Next comes Months 2 and 3 detailing the narratives for their observational and specific event data followed by a brief Term 1 review and a report on the Term 1 assessment results. Highlights from Term 2 follow as limits on thesis size prevent me from presenting the full analysis of this next three month period. The Term 2 highlights detail selected narratives of the observational and specific event data from weeks 11 to 21 of this study. A chapter review concludes this section of the thesis.
The primary observational data arose from my daily fieldnotes and daily audio recordings. This data was categorised as follows:

- S category observations were those which seemed familiar, similar or the SAME as others previously recorded.
- D category observations were those which appeared DIFFERENT from previous observations.
- C category observations were neither S nor D and hence were more like COMMENT type observations pertaining to the classroom learning environment and its participants.

These categories were determined through the planning stages of the study taking into account the experiences of the practitioner and the recommendations of the literature. The categories survived the first month of the implementation and "remained functional throughout the study" (Howard, 1995, July). When raw data observations are reported in this thesis they are identified by a number, representing the week they were recorded during, and one of these categories; S, D or C. Thus a SAME category observation from Week 7 would have the prefix 7S.

This data was synthesised each week into weekly reports and these were collated into the monthly reports presented in Appendices 2, 3, 4 and 5. The collations focused on the key areas which became apparent during Month 1 of the study. The key areas were: the student document (first principles); marks and assessments; group work ethic / process; our environment; support and criticism; listening skills; questioning skills; teacher comments and observations; tape / video recorder; specific events.

The report on Month 1 provides additional comments about each key focus area and Table 1 showed how these key focus areas evolved during the other months of this study. The key focus area group work ethic / process was further analysed under the following additional criteria: group work process; discussion and explanation; background; tasks; noise; behaviour; help; homework; observations. The last criteria, observations, are snapshots of activities and work from different lessons, that is raw data which enriches the analysed data presented each month. Some focus areas may not appear in all monthly reports for it is the nature of the data as observed and analysed that determines what can be reported. Each focus area constitutes the narrative which discusses the analysed observational data, in chronological order for that month.

The order of the focus areas is the same each month and is set according to the sequences noted above. Why that particular order? The order represents my perception of the importance of each focus area to the development of our
collaborative peer interactive classroom learning environment. My perception is borne of my readings of the literature, particularly in regards to collaborative group work. The following summary collection of quotations from the literature emphasise the importance of discussion, explanation, interaction and listening. "Fostering processes which enhance learning involves teaching students to discuss their work with their peers" (CC, 1997, p. 202). "Mathematical discussion should be a daily part of classroom activity" (Lacampagne, 1993). "Talking about mathematics means becoming actively involved in learning mathematics" (Artzt and Newman, 1990, p. 449). "In situations of cooperative learning in small groups, the verbal component of social interaction is of central importance", (Huber, 1990, p. 517). "Small groups provide a forum in which students discuss ideas, offer constructive criticism, make mistakes, learn to listen to others' ideas, ask questions and summarise their discoveries" (NCTM, 1989, p. 79). "Giving explanations requires a greater depth of understanding that goes beyond that required merely to state an answer" (Artzt and Newman, 1990, p. 449). "The constructivist classroom emphasises engaging in lots of teacher-student, student-student interaction" (Davis et al., 1990, p. 3). "The teacher should spend more time listening to students that the students spend listening to the teacher" (Lochhead, 1991, p. 78).

Group work involving discourse is the most valuable sign of collaborative education and so I wished to place this area first. By categorising my observational data into all the key areas it was then a simple task to sequence these areas according to the weight of observations each area attracted. The match between my sequencing, my 'wishes' or 'beliefs' and the literature was very close, and thus we have the data presented in the order in which it appears here.

Some other matters pertaining to the information presented in Chapter 4 are pertinent at this point. I (the author) am the 'I' in this study. I am also the 'teacher' referred to frequently in the observational data and the 'our' or 'we' refers to the students and myself. The observational data contains a mix of confirming evidence, supporting the warrant which claims successful development of our collaborative peer interactive classroom learning environment, and also disconfirming evidence, as our behaviours waned from our chosen path. These two types of evidence are not separated in the observational data but rather are situated exactly as we found them in the records of each month. Finally, a word on the references to the literature in the narratives. The observational data from this implementation has been searched for examples which reflect the multiple theoretical perspectives upon which this study is based. Thus, where findings from the literature in mathematics education, collaborative group work, or learning environments are supported or reflected in the
observational data from this study, I have highlighted the link between our practical evidence and that of the literature. I have also highlighted the links between our observations and any of the multiple theoretical frameworks which have informed this study. These include those from the literature on mathematics education, and specifically the use of collaborative group work in the learning and teaching of mathematics, as well as Vygotskian developmental theory and the constructivist referent of pedagogic practices. Many of the features from the Vygotskian and constructivist frameworks are exemplified in the observational data. Neither of these frameworks have generalised theories or specific guidelines as to classroom practices as both are more paradigmatic than practical. The usefulness of these frameworks and their paradigms lie in how readily one can identify their features in practical situations such as our collaborative peer interactive classroom learning environment. This is what my study has done. To see how, we need to start our examination of the data which begins with the following section.

This section details the Term 1 programme (Table 5) and the weekly lesson schedule for our course (Table 6). Topics were allocated time by the school as shown in Table 5 below. Topics may be generalised as follows: Shapes and Solids (Geometry); Law of Order and Integers (Arithmetic); Functions and Relations (Algebra); and Measurement 1 (Mensuration). The course contains considerable review of primary (elementary) school mathematics during Term 1 however every topic contains 'new' material.

<table>
<thead>
<tr>
<th>Topic</th>
<th>Periods</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introductory activities and issue of text</td>
<td>1</td>
</tr>
<tr>
<td>Shapes and Solids (S&amp;S)</td>
<td>6</td>
</tr>
<tr>
<td>Rule of Order (ROO)</td>
<td>5</td>
</tr>
<tr>
<td>Integers</td>
<td>9</td>
</tr>
<tr>
<td>Functions and Relations (F&amp;R)</td>
<td>9</td>
</tr>
<tr>
<td>Measurement 1 (length)</td>
<td>4</td>
</tr>
<tr>
<td>Revision and testing:</td>
<td></td>
</tr>
<tr>
<td>Review</td>
<td>2</td>
</tr>
<tr>
<td>Mid-Term 1 Test</td>
<td>1</td>
</tr>
<tr>
<td>End Term 1 Test</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>38</strong></td>
</tr>
</tbody>
</table>
Term 1 was ten weeks long and I saw the Year 8 students every school day (as shown in Table 22 in Appendix 1). Exceptions (shown as shaded blocks in Table 6 overleaf) were due to sports carnivals and official school breaks. The students first encountered this implementation when we met for the introductory lesson. The explanation took the whole lesson. One anomaly this term was the impact of the students camp. All Year 8 students go away on camp for either week 7 or week 8. Our class split evenly over this time. The lessons and content covered in week 7 were repeated in week 8 as shown in Table 6 below.

Table 6
Weekly Lesson Schedule

<table>
<thead>
<tr>
<th>Week commencing</th>
<th>Mon</th>
<th>Tues</th>
<th>Wed</th>
<th>Thurs</th>
<th>Fri</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 Feb</td>
<td>Holiday</td>
<td>S &amp; S</td>
<td>S &amp; S</td>
<td>Introduction</td>
<td>S &amp; S</td>
</tr>
<tr>
<td>8 Feb</td>
<td>S &amp; S</td>
<td>ROO</td>
<td>ROO</td>
<td>ROO</td>
<td>ROO</td>
</tr>
<tr>
<td>15 Feb</td>
<td>ROO</td>
<td>Integers</td>
<td>Integers</td>
<td>Integers</td>
<td>Integers</td>
</tr>
<tr>
<td>22 Feb</td>
<td>ROO</td>
<td>Integers</td>
<td>Integers</td>
<td>Integers</td>
<td>Integers</td>
</tr>
<tr>
<td>1 Mar</td>
<td>Integers</td>
<td>Test</td>
<td>F &amp; R₁</td>
<td>F &amp; R₂</td>
<td>F &amp; R₃</td>
</tr>
<tr>
<td>8 Mar</td>
<td>Integers</td>
<td>F &amp; R₄</td>
<td>F &amp; R₅</td>
<td>F &amp; R₆</td>
<td>F &amp; R₇</td>
</tr>
<tr>
<td>15 Mar (Camp)</td>
<td>F &amp; R₅</td>
<td>F &amp; R₆</td>
<td>F &amp; R₇</td>
<td>F &amp; R₈</td>
<td>F &amp; R₈</td>
</tr>
<tr>
<td>22 Mar (Camp)</td>
<td>F &amp; R₄</td>
<td>F &amp; R₅</td>
<td>F &amp; R₆</td>
<td>F &amp; R₇</td>
<td>F &amp; R₈</td>
</tr>
<tr>
<td>29 Mar</td>
<td>F &amp; R</td>
<td>Review</td>
<td>Term 1 Test</td>
<td>Measure 1</td>
<td>Measure 1</td>
</tr>
<tr>
<td>5 Apr</td>
<td>Measure 1</td>
<td>Measure 1</td>
<td>Review</td>
<td>Measure 1</td>
<td>Measure 1</td>
</tr>
</tbody>
</table>

Let's go to class!

**MONTHLY REVIEW #1:** February - Weeks 1 to 4 (inc)

The next section presents the narrative for the observational data collected during the first four weeks of the implementation, Month 1. The observational data referred to is presented in Appendix 2. The narrative is delineated into the categories described in Table 1 in Chapter 3. The category Group Work ethic / process is further divided into additional criteria as discussed earlier. Following the narrative for the observational data, the narrative for the data arising from the specific event for Month 1, an MCI classroom environment survey is presented. Each reflective narrative examines and highlights key points from the observed data and discusses the progress of the implementation from the context of that category.
A reminder that raw observational data is presented in Helvetica font, vignettes are presented in Bookman font, and the thesis commentary or report remains in normal Times font.

**The student document / re-focus on first principles.**

The student document, (described in detail in Chapter 3 and presented in the Appendix 1 as Figures 22 through 26), is the natural focus of the classes attention during this first week. From the students' perspective it is their guide to the way a high school mathematics class operates.

To all of us our understanding of what the document said was "crucial in establishing the routines and patterns necessary for the smooth functioning of the class" (Wood et al., 1991, p. 598).

Our initial attempts give the clear message that we will need to pay further attention to the ideas contained in this document.

Our classroom environment would need to be "continually reconstructed in the course of classroom interactions" (Cobb et al., 1992, p. 487).

**Marks for groups.**

Observations from week 1 for this category clearly highlight the perennial difficulties associated with assessment. The need to further develop the assessment processes points to the underlying reason for the students confusion on these matters. Week 2 highlights the need for a consistent approach to avert the propensity for some students to avoid completing their tasks. Discussing marks with students, highlights the continuing development of the assessment model as a negotiated class-based process rather than a teacher-imposed fact.

The following observation provides a direct example of "the role of the students in shaping classroom events" (Cooney and Hirsch, 1990).

1C - Teacher sets guide-lines on assessed work but accepts student ideas of how this can be done (incorporates students' ideas) - that is negotiation by the students is possible.

Week 3 produced little further comment on assessment apart from a note regarding our first encounter with the MCI classroom environment survey instrument. The note highlights how I avoided pressuring the students to commit to an answer for some of the
MCI's questions. This is our first survey and the environment is only three weeks old so some uncertainty is acceptable. Week 4 highlights the improvements made in the course of the first month, to the assessment procedures.

The following observation records an example of this.

1C - Recorded mental scores indicated higher levels of success than was estimated from student responses to questions.

I demonstrated these improvements by highlighting the students' improved quiz results thereby sharing the value of our collaborative efforts to develop an effective group-based assessment procedure.

It is vital to reassure the students that their marks can not be adversely affected by the sharing of results and the gaining of bonus marks within their group. At worse they are no better off than their individual result, however they can gain more marks for themselves and their group if they cooperate and work together.

This process represented one of the practical difficulties of adapting the classroom to group work, the reconciliation of that which Johnson and Johnson, (1990, p. 30), describe as "positive interdependence", working to improve group outcomes, and "individual accountability", working to improve personal outcomes. Examining this aspect of the data "informs the efforts of mathematics educators in reforming assessment practices" (Research Advisory Committee of the NCTM, 1988, p. 343).

**Group Work ethic / process.**

Early in week 1, I observed the different ways in which each group operated.

For example:

1C - Group 1 - active on the first day and have animated, high levels of discussion.

Group 2 - some discussion but 1 girl, Amanda, does not seem to interact very much.

Group 3 - good group skills but initially appeared to be dominated by Isobel.

Group 4 - appeared to be a collection of individuals and yet at times are active in discussion.

Group 5 - low level discussion, do not appear to be skilled at group work.

Group 6 - tend to discuss, think, work, re-discuss. Individuals sharing in a group.

By comparison, an observation later in the same week showed some changes in the ways each group operated:
1C - Group 1 - appeared to be discussing the task requirements then they got busy. Leader = Betty.

Group 2 - seem divided, not a team.

Group 3 - highly developed level of discussion. Leader = Isobel.

Group 4 - seem to wonder off task fairly easily.

Group 5 - are active and looking at each others work (moving around their desks).

Group 6 - still in discuss, withdraw, do, re-discuss mode, though they glance at each others work while doing their own.

This shows similar work patterns for Groups 1, 2, 3 and 6 while Group 4 exhibits less effective practices and Group 5 seems to have improved. All groups are exhibiting similar work cycles, namely organisation (noisy), individual time on task (quiet) and group discussion (noisy).

It was important to have the students develop their individual work habits within a group-based environment because "assessment practices in secondary schools require students to demonstrate their individual competence" (EDWA, 1984, p. 7-9). Group work is an approach that cannot be utilised 100% of the time.

By the end of the first week it can be seen that progress in developing our social norms has been mixed.

The following three observations highlight this.

1D - First day, quiet, attentive. Second and third days, not so quiet = good development.

1C - By Day 3 there is evidence (discussion level and details on tape) of greater collaboration on tasks. More purposeful, directed, efficient discussion is occurring.

1S - All groups lack 'social manners' in general discussion techniques.

The students are becoming comfortable with the developing environment (during week 1) and their questioning techniques are improving. They are not getting on with their work without prompting and yet there is always something to discuss. The students are still developing their classroom behaviours.

The use of the blackboard by the students in week 2 highlights the value of having students present information to the class formally. Such presentations generate considerable discussion. Week 2 gives an example of the negative side of open discussions when the students start to argue aggressively over conflicting viewpoints relating to possible solutions to a problem. Such events require greater teacher guidance to avoid debate becoming conceptually
'deconstructive' by threatening the confidence of the students in their own knowledge and in the developing learning environment. Week 2 also showed that as a teacher trying to "develop a learning environment that featured rich interactive dialogue" I was "prone to lead rather than to guide" (Voigt, 1985). It also produced evidence of the students' developing interaction skills alongside teacher led work, and of how their work cycle altered, from that described above, when they encountered consolidation tasks, as distinct from new work involving new concepts. Follow up activities mainly involved organisation (noisy) and group discussion (noisy) with the latter dominating as the following observation highlights.

2D - Activity now constitutes some small time in individual thought and work then ever increasing discussion within the group.

Two further observations from week 2 highlight how we were still coming to terms with working in a group-based environment. Firstly, not all of the students were sharing their individual work and secondly, not everyone was recording individually the tasks done collectively.

In week 3 we still did not have all students committed to assuming "more responsibility for their learning by being accountable to themselves and others" (Behounek et al., 1988, p. 12).

We do have a growing enthusiasm to use group work for all the classroom tasks. That our social norms are yet to reach full functionality is demonstrated when two students, absent from an earlier lesson, have to rely on themselves, and not their group, to help catch up on missed work. We are not yet fully supportive of each other.

Other features to emerge in week 3 included observations that being pressed for time encouraged collective effort to complete a task and that the amount we do in each lesson varies. These are fairly standard realities of classroom life.

Even after three weeks most groups are not self-starting in terms of getting on with work at the start of the lesson before the teacher gives any direction.

In fact, the observation below highlights this.

3S - Group 2 still working very much as individuals and not sharing results unless teacher suggested (directed).
A further complication, which arose in week 3, highlighted an issue of social norms which had not yet been fully addressed, namely recrimination within the group when an answer turns out to be incorrect. It was necessary for me to highlight to the students that in such instances, blame lies with all members of the group not just the source of the error. Collaboration would avoid such events, unless everyone agreed on the incorrect answer and then, of course, it would be the teacher's fault! By the end of the third week the work cycle, as observed in week 1, had been consolidated by the students as this next observation shows.

3S - Typical working sequence as the students embark on a new task / activity.
   a) Noise as they divided up the task and sort out what is to be done.
   b) Relative silence as each individual goes about her work.
   c) Emerging chatter and discussion as they progress onto sharing.

Week 4 sees much more positive progress for our collective. Groups are beginning to self start and the levels of discourse have risen significantly. The students in the class have now become more assertive in their discussions. They have become a collection of individuals each having established a place in her group and the class. We are beginning to see the emergence of the individual as a significant part of the collective as they work together in their groups and our class.

We see "people who are cooperating, working together to learn something - encouraging and depending on each other" (Kohn, 1992, p. 41).

Our reporting, to our groups or the class, has improved and our social norms are continuing to develop. However my awareness of the students' prior knowledge is inadequate during this week as we encounter evidence of boredom while studying the Rule of Order for operations and begin early work with negative numbers.

Boredom is evidence of my failing to keep the tasks above the students' actual level of development. Without activities in their 'zones of proximal development' the students were not stimulated. Once this became evident it was clear that "the actual movement in the development of the child's thinking occurs not from the individual to some state of socialisation but from the social to the individual" (Vygotsky, 1987, p. 74-76), and hence I needed to visit the students' prior experiences to exemplify the concepts from a social or collective perspective. Only by "building on and stimulating recall of prior experiences" and making these the focus of our work could I hope to "further develop these concepts" (Clarke and Kessel, 1995, July). The students saw this work as a repeat of their primary school experiences. "We need to
learn more about how perceptions relate to specific curricula experiences" (Stodolsky, Salk and Glaessner, 1991, p. 113). These observations contribute to this area of research.

(a) Discussion / Explanation
The observations from this category highlight how:
good discussion and explanation is positively contributing to our collaborative peer interactive classroom learning environment. The students have begun to take the initiative and lead the class in the discussions related to our work.
"As student's mathematical thinking continued to develop, they were able to engage in more complex and concise explanations and justifications of their solutions" (Wood et al., 1991, p. 605).
Indeed the observations highlight how:
the students are now politely taking turns during discussions although they still engage in the practice of 'all-talking-at-once' which seems just as effective.
The observations also show how the work cycle, described earlier, is evident when the students are taking notes as well as when doing activities. In fact, discussion is now difficult to stop as the following observation indicates.

2S - Now that discussion is so highly valued it is difficult for the students to do truly individual work. Some chatter occurs.

Even when working individually, the students still discuss their work. The individual models the collective. The observations also show that I need to be aware of the level of the language I am using.
Mathematical language often needs to be learnt but because students share similar language, they "can translate difficult vocabulary and expressions and use language that fellow students can understand" (Noddings, 1985). Valuing student input, a critical facet of this implementation, is noted in these observations which highlight how I used the word 'Why?', presented alternative methods and re-explained concepts. These teacher behaviours modelled effective collaborative techniques attempting to show that "collaboration involves much more than combining solution procedures to develop a joint solution. It involves developing explanations that are meaningful to someone else and trying to interpret and make sense of another's ideas and solution attempts as they evolve" (Yackel et al., 1990, p. 35). The guidance I gleaned from these observations was that increased discussion enhanced the understanding of more of the students and allowed for greater awareness and the
presentation of differing perspectives. These were all positive facets for an emerging constructivist learning environment. The value of having the students verbalise their understandings is also highlighted in the following observation.

4S - Good rapport and discourse throughout class discussion.

In order for misconceptions to be publicised and examined we all had to "observe the kind of understanding exhibited by a student" and then prompt the student "to justify what they said or did thus revealing their thinking and logic" (Pirie and Kieren, 1992, p. 509). One side effect of such processes, which the observations note, is that group consensus frequently pre-empted the need for further discussion to establish class consensus. That is the group consensus was frequently common across groups.

By far the most significant observation made in this month is the one from week 3 which describes the proximal 'zone' as open. The observation notes that the students are leading a discussion which resolves all of the mistakes encountered in completing a task. This evidence highlights the model of overlapping (multiple) 'zones of proximal development'. Learning is occurring here for as Vygotsky points out "an essential feature of learning is that it creates the zone of proximal development; learning awakens a variety of internal developmental processes that are able to operate only when the child is interacting with people in his environment and in cooperation with his peers" (Vygotsky, 1978, p. 90).
Our collaborative peer interactive classroom learning environment is developing quite well.

(b) Tasks
In reflecting on the tasks we are attempting the observations from week 2 for this category indicate that the students work better when they only have to focus on a single task and when the instructions facilitate their ability to do the task in their groups. Teacher led activity is not conducive to functional group work. The week 3 observation emphasises the need for variety among each lesson's tasks. Focusing on a single activity or process for excessively long periods of time disrupts the working environment as the activity fails to hold the students' attention. Week 4's observations point to aspects of the lessons which detract from the working environment. Confusing practical examples and the language associated with their concepts are frequently beyond the experiential world of these young
people. The final observation reflects that made in week 2, namely single-focus tasks work best. A further observation about the use of concrete aids was made during week 4 as follows.

4D - Manipulatives were introduced to assist in the activities. 'Play time' is required at this stage as the students familiarise themselves with the equipment.

Teachers and researchers alike will recognise this 'play-time' when manipulatives are utilised in the classroom.

(c) Help
The observations from this category illustrate the students' progress in developing the necessary social norms for our collaborative peer interactive classroom learning environment. By requiring the students to actively seek help when they perceive they need it I am adding the extra dimension to the collaborative process which the literature has suggested was lacking in earlier collaborative learning environment studies.

"Preparation includes developing communication skills and encouraging prosocial behaviour (e.g. Solomon, Watson, Schaps, Battisiticich and Solomon, 1990), but does not include specific training on giving and receiving help" (Webb and Farivar, 1994, p. 372). By the end of the third week I noted the following observation.

3S - Students refer to each other when they need to know something.

(d) Month review - Group Work ethic / process
In reviewing the month from the Group Work ethic / process perspective I notice that we have developed a relaxed air quite early on. A significant summary observation is how group activity varied widely both within one group, from day to day, and across groups on the same day - a variation which reflects the typical behaviour / work ethic of individuals. I believe these observations make a strong case for how a group's functions parallel that which I had previously observed as individual functions. So we can see how our functional collective acts / reacts in much the same way as does an individual. The better the functioning of a group the more like an individual it (the group) becomes.
Other summative observations of the Group Work ethic / process from month 1 are given below:

2S - Many students are not keeping complete records of work done by whole class. Student work will need to be monitored more.
4S - In enacting a task groups followed the regular routine of noisy division of tasks then quiet working on tasks then noisy discussion in groups of the solutions.

This observation has been made on several occasions.

4C - When groups work together on an exercise they do not subsequently have to negotiate a group solution as they all have the same answers (right or wrong).
4S - Groups working well at dividing up tasks and getting on with activities.
4S - As groups work there is much discussion between group members, between groups and between the teacher and the students. A happy collaborative environment for nearly all to work in.

By the end of the first month we have the observation that our collaborative peer interactive classroom learning environment is developing well.

The passage recorded in Appendix 2.1.7 illustrates the typical group work process evident by the end of the first month and indicates how I gave the students initial instruction in the task, making the task accessible to them individually or through collaboration with their peers.

"This is a fundamental characteristic of instruction. Therefore, the 'zone of proximal development', which determines the domain of transitions that are accessible to the child, is a defining feature of the relationship between instruction and development" (Vygotsky, 1987, p. 211). This guidance ensured the students had adequate knowledge of the task requirements. "The accumulation of knowledge leads directly to an increase in the level of 'scientific' thinking and this, in turn, influences the development of 'spontaneous' thinking. This demonstrates the leading role of instruction in the development of the school child" (Vygotsky, 1987, p. 168). The task exemplifies a typical open-ended problem solving activity in which the students frequently engaged (NCTM, 1980). Within this passage we can again see the full spectrum of the emerging collaborative process (as emphasised by the underlining in Appendix 2.1.7).
Initially the "students work independently" which is an important part of their developing understanding (EDWA, 1984, p. 7-9). As I withdrew my guidance the students became more collaborative and hence more effective problem solvers. In other words I had influenced the students' "social behaviour on achieving the mathematical learning outcomes, a role closer to a Vygotskian approach" (Higgins, 1995, April, p. 9). When I accepted the bid of four as a solution, I facilitated "the students' mathematical development by subtly highlighting selected aspects of their mathematical contributions" (Yackel et al., 1990, p. 35). The students' "learning requires that existing ideas be challenged and this may occur when they find that others think about a problem in a different way" (CC, 1997, p. 199), which is what I had just demonstrated. The students then opened up with further discussion and suggestions of other possible solutions, reflecting our 'constructivist' approach to classroom interaction. "Students will perform better and learn more in a caring environment in which they feel free to explore mathematical ideas, ask questions, discuss their ideas, and make mistakes" (NCTM, 1989, p. 69). "A supportive environment for learning encourages risk-taking and regards errors as a necessary, acceptable and often helpful part of learning" (CC, 1997, p. 202). The intense level of discussion which ensued reflected a high degree of intersubjectivity, "a process of interchange, a dynamic during which meanings are chosen from a repertoire of social language and experience" (Solomon, 1994, p. 15).

This passage highlights how our collaborative peer interactive classroom learning environment nurtured and developed classroom norms such as seeking clarification, talking about our own ideas, listening and responding to the ideas of others and "building on other students' ideas" (Vacc, 1993, p. 225). By adopting a group work ethic we had developed "a forum in which students ask questions, discuss ideas, make mistakes, learn to listen to others' ideas, offer constructive criticism, and summarise their discoveries" (NCTM, 1989, p. 79) further enhancing our 'constructivist' approach.

The students are actively engaged in reflection, collaboration and negotiation as they develop their understanding and determine solutions to the problem tasks based on their newly formed 'taken-as-shared' meanings of the concepts involved.

For students to become effective learners of mathematics, they must be actively engaged, want and be able to take on the challenge, persist in effort and take risks. For this to occur the student must personally experience a supportive environment, with mathematical challenges, which promotes and enhances sustained and robust learning (CC, 1998, p. 206).

Our learning environment has matured nicely.
Thus we have the "interdependence of the process of child development and the socially provided resources for that development" (Valsiner, 1988; p. 145) as the students engage in collaborative activity.

Ours is a dynamic environment embracing the changing developmental progress of the student as she collaborates with others. The passage shows the students working in and through their collective 'zones of proximal development'. "The focus is on the social system within which we hope children learn, with the understanding that this social system is mutually and actively created by teacher and students. This interdependence of adult and child is central to Vygotskian approaches" (Moll, 1990, p. 11). Initially an activity is bound to be below some students' actual developmental level and above others potential developmental level and thus not within their existing individual 'zone of proximal development'. However, by working collaboratively, all students should be able to get or give help as their knowledge requires or allows, and thus all should benefit from the activity. This study endeavoured to create "a classroom environment that allowed the social nature of learning to be expressed thus leading to increased learning" (Newman and Holzman, 1993, p. 70). Much of what this study is about can be seen in this passage. Let us continue to reflect on the observations from Month 1.

The environment - group size and effect.
The observations from week 1 for this category focus on initial organisational aspects of the developing environment with particular interest in control and making the students feel at ease.
One further influence on the pace of class work, other than that observed, is the weekly lesson schedule, (Table 6), which controlled the number of lessons available for each topic. This is one of the main external influences discussed in earlier chapters.
Week 2's observations continue the focus from week 1. The key point as to the effects on the environment is the observation that verbalising solutions aids discussion.
From this I was encouraged to elicit more student comment on their work which in turn encouraged others to contribute and hence discuss their work.
Week 3 points to further 'administrative' issues for the environment while week 4 highlights the first significant breakdown of the group process with an intra-group conflict coming to the teacher's (my) awareness. Peer interaction can often highlight and frequently
overcome difficulties of which teachers are unaware and might otherwise go unattended. Many of the students’ concerns, which cannot be foreseen by the teacher, can come out in the group discourse and be resolved, or at least flagged as a problem, by the group. For the students concerned, Group 1, the use of a collaborative environment certainly brought their difficulties to the fore and subsequently allowed them to resolve the issues and hence achieve significant progress in personal and collective growth. An interesting observation, from week 1, which received additional reference is shown below. This observation is pertinent to the emergence of subsequent events for Group 1.

1D - 3 person groups (numbers 2 and 5) do not seem to be functioning as well as the 4 person groups (numbers 3, 4 and 6) - the exception being Group 1.

**Student support and criticism of each other and the teacher.**

A collaborative environment thrives on support and criticism through discourse among the participants. The observations from this category show how such procedures emerged in week 1 and continue to develop during the first month.

By the end of week 2 we had a:

2C - Good ‘rapport’ developing and the ‘teacher expert’ factor diminishing as the students develop the confidence to tell the teacher when he is wrong.

**Discussion not only facilitates learning, it also enhances social skills within a collaborative classroom.**

"By listening to students' ideas and encouraging them to listen to one another, one can establish an atmosphere of mutual respect" (NCTM, 1989, p. 69). Further observations from week 3 highlight other developments from our collaborative peer interactive classroom learning environment.

3D - When sampled - several students said their group had improved their personal responses in an activity - none said the group had given them incorrect responses. This showed to the students the value of the group to them.

3D - The teacher given solutions led to a class discussion of mistakes and resolution of these. Control belonged to those who knew the correct technique, and each group had such a person. Therefore, the proximal ‘zone’ was open and peer teaching was in full swing.
Evidence of activity within individual's 'zones of proximal development' or across the classwide 'zone of proximal development' resides in seeing the students teaching other students. Not only does this "emphasise the role of students in shaping classroom events" (Cooney and Hirsch, 1990) it also highlights "Vygotsky's conception of the zone of proximal development which stresses the child's ability to profit from interaction with more competent peers" (Damon and Phelps, 1989; Vygotsky, 1978). One additional observation from week 3, shown below, gives particular importance to a vital social norm within such environments, namely concentrating on ensuring that students' ideas and opinions were valued and acknowledging that they could resolve each other's difficulties.

3S - Questions unresolved within groups are put to the class. Such questions exist because the whole group shares the incorrect solution or because the explanations by those within the group is inadequate and further input is needed.

By week 4 the students have graduated to 'the front of the class'. We truly are becoming a "classroom of 22 teachers" (Behounek et al., 1988).

By encouraging discussion, our environment also revealed to some of the students that not everybody shares our viewpoint, so through our interactions with other people we are able to "constantly adjust our understanding and interpretation of phenomena" (AEC, 1990, p. 19). "Explaining something to a peer usually leads to seeing things more clearly and often to spotting inconsistencies in one's own thoughts - a process which provides a wonderful opportunity for learning" (von Glasersfeld, 1993, p. 31). The final observation from this section shows how, in just one week, a problem can be observed - not finishing exercises - and a solution developed and implemented - teacher asks groups to ensure that everyone has all the answers. The solution further enhanced the benefits to be gained from working in a collaborative peer interactive classroom learning environment.

Student listening skills.
Coupled to the very important role of support and criticism comes the skill of listening.

The observations from this category indicate that listening skills have not developed very far in the first month. The value of reading to enhance understanding emerged during week 4.

A further observation, noted below, cautions the teacher from focusing on only the 'polite' forms of discourse. The value of 'multiple' talk, where many people talk and listen simultaneously, was also recognised.
2S - Within the groups most students seem to be taking turns to explain ideas. This is polite and considered courteous but I do not think it should be valued over 'multiple' talk as this too can be effective.

![Figure 7](image)

Group 1: Cathy, Betty and Jenny

**Student questioning skills.**

The observations from this category show how, in week 1, the students focus their questions on the teacher rather than their group and how by week 2 this has evolved into questioning the teacher. The developing environment has afforded the students the confidence to do this. Reflecting questions back to the students for resolution reflects behaviours which fit well with the concept of a 'constructivist' classroom as does the use of the students' prior knowledge to facilitate resolution.
"We must value and respect what the student knows - not just because of constructivism but because doing so enhances the students' self esteem / worth" (Bickmore-Brand, 1993). Being aware of the students' prior knowledge and experiences and utilising these wherever possible is a principal focus of the 'constructivist' classroom environment and hence is also a focus for our collaborative peer interactive classroom learning environment.

The students' existing knowledge should be recognised and used as the starting point for further learning. It should be extended to include the complementary knowledge, with the new knowledge being linked to, building on and challenging the students' existing ideas and strategies, so that over time they develop mathematical understandings which are both commonly accepted and over which they feel some ownership (CC, 1998, p. 208).

Additional information from these observations relates to how the students are still more reliant on the teacher than on each other when new concepts are introduced.

**Teacher use of student features.**

At the time this study commenced I was well versed in the required behaviours of a teacher working in a collaborative learning environment.

As the week 1 observations from this category show, I have reduced the amount of teacher talk or lecturing, am using the students' ideas, building on their questions and using their prior knowledge, although this aspect needs further improvement.

There was also evidence that my listening skills had improved and since "teachers need to listen to students and utilise what they learn from listening" (Lacampagne, 1993) I was in a better position to respond to the students' needs. I had also improved my handling of students' questions as the following observation highlights.

1S - Redirecting student question to the students to answer is a well developed teacher skill.

In addition to honing my collaborative learning environment skills my ethnography skills are also developing as I manage the demands of teacher researcher and seek advantage from each role to assist the other.

"New teaching strategies are extremely difficult to learn and to set oneself to learn, especially when they cut across old habits and assumptions and invalidate hard-won skills. Nevertheless it is true that strategies can only be developed in the classroom" (Stenhouse, 1975, p. 25).
All is not perfect however as the week 1 observations show. I am still answering some student questions rather than redirecting them to the groups for resolution.

"Teachers' roles begin to shift from 'telling and describing' to 'listening and questioning' and 'probing for understanding', although the shift occurs at varying rates and to varying extents among teachers" (Maher and Alston, 1990, p. 161).

"Even teachers who try to develop learning environments that feature rich interactive dialogue are prone to lead rather than to guide" (Voigt, 1985).

This aspect of my teaching technique needs further improvement and monitoring. One area that has improved is my class instruction which the observations note in both week 1 and week 2. Poor instruction leads to the students asking clarifying questions and much of the improvement in this regard has come about since I began asking the students to confirm instructions. This highlights any misinterpretations and also translates the instructions into the students' own language which often better suits their peers. All of this positively facilitates getting on with the tasks at hand in our groups.

Developing a functional collaborative peer interactive classroom learning environment is about developing the students and their attitudes and sense of worth. Observations from this category for week 2 note how I endeavoured to boost the students' morale thereby building their self esteem, features valued by Gallimore and Tharpe who encourage the "maintenance of a positive classroom atmosphere" (1990, p. 198) and by Cockcroft who reminds us that "positive attitudes assist the learning of mathematics" (Cockcroft, 1982, p. 101). Giving the students praise for their successes further enhanced our developing collaborative peer interactive classroom learning environment since, as Chance reminds us, "there is overwhelming evidence that certain rewards (e.g. praise) are almost always effective reinforcers when used properly" (1993, p. 789). Other observations from this category for week 2 served to remind me of the value and importance of student opinions and how these must be followed up in our discussions for it was my obligation to "listen to the students' ideas and respect their mathematical thinking" (Wood et al., 1991, p. 600).

In week 2 I observed the need for greater re-direction of student questions to reduce the teacher-is-expert factor within our collaborative environment. Observations from week 3 for this category show how this need is successfully addressed. The teacher became uncertain. Teacher 'ignorance' or uncertainty encourages the
students to question and debate the ideas and concepts being studied.
Once the students "realised they could not completely trust their instructor" (Lochhead, 1992, p. 551) they engaged in enhanced levels of discussion and gave more explanation which led to clearer statements of solutions for problems. The following observations illustrate these points.

3C - Collective marking by the teacher of solutions to exercises: The teacher says 'the answers, I think, are ...' which leaves open the possibility of teacher error and encourages the students to ask and double check problems or different answers - this did happen - (important teaching point).

3C - Students often ask questions to which they have the answer/knowledge required for a solution and if the teacher is answering the student via other questions then the teacher can often redirect or refocus the student's knowledge/understanding to solve their problem using what they already know.

All of this is encapsulated within their own level of language. Students "can translate difficult vocabulary and expressions and use language that fellow students can understand" (Noddings, 1985). The result is a powerful technique (teacher 'ignorance') that gives ownership of the discourse and outcomes to the students.
These techniques pull together a variety of best practice methods from within collaborative learning. "Collaboration involves much more than combining solution procedures to develop a joint solution. It involves developing explanations that are meaningful to someone else and trying to interpret and make sense of another's ideas and solution attempts as they evolve" (Yackel et al., 1990, p. 35).

Having the students develop their solutions through discussion and hence use their own language level helps spread understanding across the class.
"Students may understand better than their teacher what other students do not understand" (Vedder, 1985).

Developing techniques which enhance the students role within, and potentially benefit, our collaborative peer interactive classroom learning environment is a focus for me during this first month of our implementation. My own personal development is caught up in such progress as I endeavour to close the gap between the students' 'everyday' and 'scientific' concepts.
"The Vygotskian teacher will devise various ways of achieving this" (Boomer, 1986, p. 4).
The observations from week 3 for this category also indicate that I am a creature of old habits as the pace of my teaching over-ran the students' capacity to learn. One modification I can make to ease this situation is to reduce the amount of instruction to an outline of the task, leaving the organisational and procedural details to the students in their groups. In addition I can endeavour to model good group work practices including repeating the points raised by others in our discussions and asking clarifying questions. This next observation highlights these points.

3S - The teacher emphasises student points and questions and clarifies when needed. This is a meritorious model for the students to follow in their work groups.

These techniques were very useful "in establishing the routines and patterns necessary for the smooth functioning of the class" (Wood et al., 1991, p. 598). Thus the teacher can build up student confidence by using the students' answers and the students' ideas. When necessary the teacher can illustrate or clarify things further through step by step instructions but the vital component is allowing everyone to have their say. "The teacher facilitates the students' mathematical development by subtly highlighting selected aspects of their mathematical contributions" (Yackel et al., 1990, p. 35). Each of the following observations represents aspects of such teacher facilitation.

3C - The teacher takes the student's alternative answers and asks the student to explain (orally / verbally) how they got their answer which almost always leads to their discovery of how they did the question and therefore where they probably went wrong - (important learning point).

3C - The teacher emphasised the value of verbalising solutions in making things clearer.

3S - The teacher attempted to let everyone have a say if they wished and attempted to incorporate and value the input or idea.

The students can be stubborn sometimes, but if the teacher is to value and respect the students' input, then the teacher must attempt to incorporate the old values and experiences to which the students still cling into the further development of the concepts being studied. This next observation sets the focus on to the students and on to the desire to build concepts on the students' prior knowledge base.
3S - Student confidence to speak up is built up by the teacher continually using student answers and ideas. That is it is hoped that the students see the curriculum building from their own initiatives.

Observations from week 4 for this category show the continuance of the trend to devalue the teacher-as-expert factor and illustrate how, by this time, the students accept teacher error. The point is made however that this acceptance is tenuous at best and that the teacher must maintain his or her role as an equal lest the students return to the situation of expecting to get all the answers from the teacher.

Answers reside within oneself and within one’s group. The teacher simply facilitates the students’ discovery of these answers. The aim is to always "minimise teacher dependency because children assume more responsibility for their learning by being accountable to themselves and others" (Behounek et al., 1988, p. 12).

Also noted in the observations from this category for week 4 is the notion of a proximal 'zone' work environment in which the teacher moves around, "teachers beginning group work with their classes will find that they (the teacher) are moving around the room constantly" (EDWA, 1984, p. 40), discussing solutions and methods, giving hints and suggestions for "one of the teacher's responsibilities is to help children learn how to engage in collaborative dialogue about mathematics" (Wood and Yackel, 1990). This activity, on the part of the teacher, spans the full range of student proximal 'zones'.

I am working within the classwide proximal 'zone' and I am also determining the extent of this 'zone' to inform my next teaching phase.

"Within the overlapping (multiple) 'zones', students navigate by different routes and at different rates. These rates are constantly changing as participants become increasingly independent at successively more advanced levels" (Brown, 1994, p. 7). Thus it is that the dynamic nature of the 'zones of proximal development' become apparent through our observations of the interactions between the students and the teacher who make up this classroom.

We should think of the zone of proximal development as characteristic not solely of the child or of the teaching but of the child engaged in collaborative activity within specific social environments. The focus is on the social system within which we hope children learn, with the understanding that this social system is mutually and actively created by teacher and students. This interdependence of adult and child is central to Vygotskian analysis of instruction (Moll, 1990, p. 11).
The important point here is that the 'zone' is created through social interaction and so each and every interaction re-creates the 'zone'. It is dynamic and developing along with the students.

We must also remember that these student-teacher interactions "invoke development of the 'zone of proximal development' by causing each other to think about their thinking, that is metacognitive processing" (Goos and Geiger, 1995, July). The observations in week 4 for this category noted how I positively guided the students through tasks, re-directing their thinking by "making them think about and reflect on their thinking" (EDWA, 1984, p. 7). The next observation highlights this point.

4S - The teacher used a student's misconception to refocus the student's thoughts, explain the details, and rebuild the concept.

Another technique which I utilised to re-focus thinking was simply allowing the discussion to come to a stop when no one could answer a question. Students want to fill such vacant spaces and will eventually put forward an idea which the discussion can use to go forward as this next observation shows.

4S - The lesson is diverted to follow a student's idea. That is content became student led.

Learning about individual, group and classwide proximal levels within our environment often means giving examples which are beyond the students' experience, beyond their proximal (individual and collective) levels.

This usually resulted in the students not accepting or understanding the concept as this next observation notes.

4D - The teacher gave examples of a new concept beyond the students' experience. The example proved to be beyond the proximal level for many of the students and so they were unable to accept the concept. Some students were able to understand the work. The class divided into able and not able.

It was also observed that building on students' ideas, using their prior knowledge as a basis for discussion of new concepts, could also lead to confusion about the topic being studied as shown in the observation below.

4S - The very good level of student discussion leads to the exposure of quite a lot of student uncertainties on the topic.
These differences or uncertainties are not uncommon in a group of students drawn from a diverse range of backgrounds as was this class. "The differences in entering knowledge and understandings will determine that individual students are likely to construct substantially different understandings" (Zevenbergen, 1995, p. 77). This also holds true for the teacher.

As the first month draws to a close it is quite evident from the observations that many of the beliefs I have formulated through my preparation for this study have been significantly altered in the classroom, while others have become established norms of my practice.

There were still some deficiencies, as observation 4D below indicates, and there were many successes, as observation 4S below shows, all of which set the tone for an interesting, even exciting, second month.

4D - The teacher gave answers to questions which some students had missed last lesson - MISTAKE - the teacher should have let each group give these answers.

4S - The teacher used students to illustrate problem solutions on the board, valuing the students' work.

Tape Recorder,
One further area under observation involves the ethnographic process. The use of the tape recorder features in Month 1. As an object in our classroom it quickly loses the attention of the students unless they come into close proximity with it (week 4). As a device for recording events it is invaluable to me in enriching the fieldnotes I am able to make during each lesson.

Disconfirming Evidence
During Month 1 many instances of disconfirming evidence were recorded and noted in the observations, vignettes and associated narratives. This evidence is further highlighted below, in summary form, to exemplify possible limitations in the implementation. Limitations are discussed in Chapter 5.

• initial attempts to utilise the ideas recorded in the student documentation needed further development
• difficulties associated with assessment were apparent
• student confusion with assessment procedures
• the need to reassure the students that their marks could not be adversely affected by sharing results
• students avoiding completing tasks
• Group 2 – seem divided, not a team
• Group 4 – seem to wander off task easily
• by the end of the first week our progress in developing our social norms had been mixed
• 1S – All groups lack 'social manners' in general discussions
• the students were not getting on with their work without prompting
• the students argued aggressively over conflicting solutions to a problem
• not all of the students were sharing their work
• not all of the students were recording individually the work done collectively
• 2S – many students are not keeping complete records of work done by the whole class
• some students were still not being responsible nor accountable for their learning of the learning of others
• students cannot rely on their groups to catch up on missed work
• 4D – The teacher gave answers to questions which some students had missed last lesson – MISTAKE – the teacher should have let each group give these answers
• groups were not self-starting
• 3S – Group 2 still working very much as individuals and not sharing results
• within group recriminations occur when answers are incorrect
• the teacher's awareness of student prior knowledge is inadequate
• using the students' prior knowledge needed further improvement
• the teacher needed reminding as to the value and importance of student opinions and how these must be followed up
• using the students' prior knowledge could lead to confusion about a topic
• evidence of boredom reflecting work below the students' actual level of development
• the teacher gave examples which were beyond the students' experiences, beyond their proximal (individual and collective) level of development
• the teacher's level of language was not facilitating understanding
• multiple task activities were not succeeding
• lessons need a variety of tasks
• excessively long tasks disrupt the working environment as they fail to hold the students' attention
• teacher led activity was not conducive to functional group work
• an intra-group conflict led to the first significant breakdown of the group process
• the teacher had to elicit more student comment on their work
• 1D – three person groups do not seem to be functioning as well as the four person groups
• listening skills had not developed very far
• the teacher had to change his perceptions on what was 'right' regarding functional and effective forms of discourse
• the students focus their questions on the teacher rather than their group
• the students are still more reliant on the teacher than on each other
• the teacher was still answering student questions rather than redirecting them to their group
• there was a need to reduce the 'teacher-is-expert' factor by redirecting questions
• the pace of teaching over-ran the students' capacity to learn
• the teacher needed to refocus the students' thinking by allowing discussion to come to a halt

In the next section we will examine the specific event from Month 1 which was the My Class Inventory classroom learning environment survey data collected in week 3.

My Class Inventory (MCI #1) - week 3

Another indicator of the functioning of our collaborative peer interactive classroom learning environment was the learning environment questionnaire, the My Class Inventory, or MCI as we called it. This was the principal means of monitoring our emerging collaborative peer interactive classroom learning environment. From the data collected through the MCI, shown in Table 7 overleaf class and group charts were produced and these are shown as Figures 8 and 9 on the following pages. These were analysed to determine future actions aimed at further developing our collaborative peer interactive classroom learning environment along the lines we desired and within our theoretical and practical guidelines.

The charts were presented to the students and the outcomes were discussed in class. A transcription of this discussion is presented in Appendix 2.2.

This transcript is the first, somewhat tentative, attempt by the teacher to talk to the students about how the collaborative peer interactive classroom learning environment is developing. From the class perspective the students have high levels of satisfaction and cohesiveness within the class and yet they would like even higher levels of these attributes. The levels of difficulty and friction are low but the students would like even less and the high level of competitiveness needs to drop down quite a lot. This latter attribute possibly involved establishing one's self in the class at this early stage, and may be less obvious and hence fall in value after the next month or so.
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**Group 1 A**

| Averages | P  | 14.3 | 7.0 | 5.7 | 7.0 | 11.7 |

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**Group 3 A**

| Averages | P  | 14.0 | 5.0 | 7.5 | 5.8 | 10.0 |

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**Group 5 A**

| Averages | P  | 15.0 | 5.0 | 7.7 | 5.7 | 13.0 |

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**Group 6 A**

| Averages | P  | 14.5 | 6.0 | 7.5 | 6.0 | 12.8 |

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**Group 4 A**

| Averages | P  | 15.0 | 5.5 | 7.0 | 5.5 | 12.5 |

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| Averages | P  | 14.6 | 5.6 | 7.1 | 6.4 | 12.7 |

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Table 7: MCI 1

Student summary data.

Group data and Class data.
Figure 8
MCI 1 Class Graph
Figure 9
MCI 1 Group graphs
Group 1's results mirrored the class data except for cohesiveness and friction. The Friction (F) scale examines student perceptions of each other by asking about the levels of agreement and disagreement among the group members and how well they get along. This was a problem for Group 1 at this stage and also for Group 5 who preferred a lot less friction in their group than they had. Group 1 had some difficulties during the first month and these results reflected their poor start to group development. Group 2 had a very good set of results in that their actual and preferred values differed by little in all but the Cohesiveness scale which reflected the class outcome for this attribute. The Cohesiveness scale (Ch) determines student perceptions about friendships between students in the class and the extent to which the students know each other. Group 2, like Groups 1, 3 and 5, had quite a bit to learn about each other. Group 3 had a good match on three of the scales but not on Cohesiveness or Competition for which it had the widest disparity of all the groups. The Competitiveness (Cm) scale looks at the degree to which the students compete to finish first or are concerned about not keeping up with each other. Group 3 sought a lot less competitiveness in its functioning and needed to develop more collaborative attitudes and practices for this change to occur.

Group 4 had a 'class typical' chart except that they expressed greatest concern over the difficulty of the work. The Difficulty (D) scale represents student perceptions about the difficulty of the classwork and the ability of themselves and others to do their subject work. Group 4 appeared, at this stage, to be the least able mathematically and this outcome appeared to support my observations of the students. Group 5 also had a 'class typical' chart except for the Friction scale, mentioned earlier, and the Satisfaction scale. The Satisfaction (S) scale measures student perceptions of the extent to which they and their peers enjoy the class and the work they do. Group 5 was the least satisfied of all the groups which indicated that they do not like the work they have been doing and that they are not enjoying the class as much as they would like. Group 6 had a high level of satisfaction but they would have liked more as would most of the class and this now became a focus for us as we continued to develop our collaborative peer interactive classroom learning environment. The results for Group 6 produced the best match for the scales of any single group. Group 6 would have liked a little more cohesiveness and a little less competitiveness, things with which their class mates concurred, and which may come to pass as we all became more effective collaborators. In all such analysis, some specific, individual results from the MCI survey had been generalised, into group results and then a class result, in order to allow for "individual accountability" and "positive interdependence" (Johnson and Johnson, 1990, p. 30). Thus it was that
the individual's opinion mattered and was pivotal in influencing the future processes of our collective learning environment. This may then resolve the paradox alluded to earlier in Chapter 2. Now perhaps we can see how the individual and the group can grow and flourish together in the one collaborative peer interactive classroom learning environment.

In the transcription I also reinforced to the students the information regarding the role these assessments play. The MCI does not count for marks or grades but for how we work and learn in class. It is information that helps us to improve our environment. It reflects each student's opinion which matters more than anything else, and even though the outcomes may take time to become evident we must keep working towards the goals of improving our environment.

Rewards achieved "over a period of days or weeks do not diminish motivation" (Vasta et al., 1978). The transcription also highlights the actions taken or planned to be taken as regards effecting improvements to our collaborative peer interactive classroom learning environment in line with the trends requested by the students and as shown in the MCI data.

I have tried to increase enjoyment, decrease conflict and give more information. I have tried less talk, more action and greater levels of explanation.

Such negotiations are "crucial in establishing the routines and patterns necessary for the smooth functioning of the class" (Wood et al., 1991, p. 598). Student responses to these changes were quite positive as reflected in the transcript. The characteristic work sequence is described in the transcript and was offered to the students as an example of our progress in improving our collaborative practices. The importance of these outcomes as a measure of student opinion is again emphasised in the transcript.

"Classroom interactions should be characterised by a genuine commitment to communicate in which the teacher assumes that students' actions are reasonable from their perspectives even if that sense is not immediately apparent to the teacher" (Cobb et al., 1992, p. 486). I also gave the students time to reflect on and share the MCI results to enhance their understanding of the information it presented to them.
MONTHLY REVIEW #2: March - Weeks 5 to 7 (inc)

This next section presents the narrative for the observational data collected during weeks 5, 6, and 7 of the implementation, Month 2. The observational data referred to is presented in Appendix 3. The narrative is delineated into the categories described in Table 1, and is similar in structure to Month 1. The category Group Work ethic/process is further divided into additional criteria as discussed earlier. Following the narrative for the observational data, the narrative for the data arising from specific events is presented. For Month 2 these include the results of the second MCI classroom environment survey and the Mid-Term 1 test, a report on group work in other subjects and Buddy reports (partial data as some students were away on camp and completed these reports subsequently). Each reflective narrative examines and highlights key points from the observed data and discusses the progress of the implementation from the context of that category.

A reminder that raw observational data is presented in Helvetica font, vignettes are presented in Bookman font, and the thesis commentary or report remains in normal Times font.

The student document / re-focus on first principles.
The observation from this category highlights the need for collaborative classes to be reminded about what they are supposed to be as they develop. No one knows it all straight away.
Implementing such environments is a continuous process and like other researchers we found that our collaborative classroom social norms were "continually reconstructed in the course of classroom interactions" (Cobb et al., 1992, p. 487; Voigt, 1985; Mehan, 1979). We also found that the majority of this renegotiation occurred in the early part of the year "although norms were continually renegotiated and reinterpreted throughout the school year" (Yackel et al., 1991, p. 400).

Assessment.
With their first class test looming in week 6 the students have a definite focus on this event during this month. The observation for this category from week 5 serves to indicate how I followed up on needs identified in Month 1. A more consistent approach to and worthwhile enhancement of homework practices is accepted by the students. This initiative is again commented on in the observations for this category from week 6. Details of the administration of the test, the administration of the second MCI and the reporting back to
the students about the first MCI. are also outlined in the
observations for this category from week 6. Student reactions to the
test, done as individuals, seems quite positive. Student reactions to
the results of the first MCI are quite animated. The data presents the
students with a new perspective of themselves and causes them to
consider thoughtfully the impact of these results. By week 7 the
observations from this category show how I have reduced my level of
guidance to that of monitoring the groups as I move around the
room.
By engaging in discussions with the students and their groups I was fulfilling one of
my responsibilities of "helping children learn how to engage in collaborative
dialogue about mathematics" (Wood and Yackel, 1990).
As I move around the room I encourage the students to challenge
each others thinking.
Such interactions embodies "a phenomenon that occurs as part of the educational
process, a cooperative process" (Vygotsky, 1987, p. 169) - a process that aids
concept development.

Group Work ethic / process.
In addition to developments in earlier group work processes, (week 2 - use of the
blackboard by students), weeks 5, 6 and 7 saw an increase in the role of visualisation
in student problem solving endeavours.

5C - Should use student demonstrations more often.

I seek to have the students visualise processes and solutions and act
out processes and solutions physically. This frequently results in the
reversal of the student / teacher roles as the students take over
instructing the class.
In collaborative classrooms engaged in peer interaction student / teacher "roles may
be easily reversed" (Forman and Cazden, 1985, p. 329).
Such activity also emphasises how play and interaction, which these
practices model, benefit our learning environment.
"Students progressed through stages of play, peer and teacher interaction when
engaged in problem solving" (Rogoff and Wertsch, 1984, p. 61-62). These activities
represent a "domain of transitions that are accessible to the students" and thus help
"define the relationship between instruction and development" within the classwide
'zone of proximal development' (Vygotsky, 1987, p. 211). They thus assist the
teacher to identify a "zone range" within which to focus instruction (Tudge, 1992, p.
1365). As well as these new initiatives, this month saw an increase in my attempts to explain concepts using many and varied examples. Each approach worked for some, but not all, of the students. That is why they were introduced. A variety of techniques, as this next observation shows, should cover all of the class.

7C - The students indicated a diverse range of preferences in methods and the teacher suggested they use their favourite.

The topics being studied at this time, Integers then Functions and Relations (Algebra), present many opportunities to link physical activity with mathematical conceptual development. Other examples of group work process evident this month included:

5C - When the teacher went over the solutions the class had little to say except within their own groups where they sought to confirm examples.

The above observation highlights one of the benefits of working in a group and this next observation reinforces the value of providing a diverse range of approaches many of which were student sourced.

5D - Student volunteers came forward to illustrate solutions to some teacher set problems. The class modified the volunteers work until all were happy it was correct.

These processes had evolved from our group work and "social norms which valued each other's ideas" (Vacc, 1993, p. 225). The negotiation of these norms "had made possible the negotiation of mathematical meaning" (Lo and Wheatley, 1994, p. 145).

Group work processes, which were similar this month to those we had seen last month, included the following observation which highlights the continuing importance of a constructivist, student-centred approach to this study where differing views can be negotiated into one view as students "construct their own knowledge individually and collectively" (Davis et al., 1990, p. 3).

5S - Class discussion of solutions was based totally on student answers. Groups also discuss solutions among their members.

Noting the following observation illustrates a difficulty for constructivist oriented teachers, where students remain loyal to their prior knowledge.
5S - Classroom interaction practices seem to be leading to a resolution of the concept but it is a slow process for some who still cling to their old ways.

"The difficulty is that here, and in general, 'running with the student's idea' and 'tying knowledge to well-established structures' might well be in conflict" (Arcavi and Schoenfeld, 1992, p. 331). Another familiar observation is shown below.

6S - Groups are working and discussing new activities but the teacher still needs to emphasise the group focus idea to enhance sharing.

This shows that the students still required assistance in utilising their group work skills. We also noted the consolidation of the group work process which was evident in the following week 7 observation.

7S - The usual work ethic is in evidence. Very low levels of discussion as the students work on the activities then increasing discussion as they begin to compare results and prepare for the class discussion of the solutions.

Some observations, for this category from month 2, were not as familiar to us. For example, the following observation shows how the teacher helped a student develop their thinking to overcome a misconception.

5D - The teacher analyses, on the spot, an incorrect student answer and then uses this analysis to redirect the students' focus so she can acknowledge that the original comment was an error yet still save face from the discussion.

I preferred this to the alternative of simply pointing out she was wrong. That students could "make mistakes and do so in front of the class" was a strong sign of the effectiveness of our collaborative peer interactive classroom learning environment (NCTM, 1989, p. 79).

We have learned that there was a great deal to gain by examining our mistakes.

"To learn from a challenge or conflict, the student must recognise it and see errors as a useful source of feedback" (CC, 1998, p. 207). This situation also shows how I modelled an often overlooked yet invaluable collaborative behaviour, that of "giving help" (Webb and Farivar, 1994, p. 372). A technique, implemented this month, to strengthen group work can be seen in this next observation.

6D - The teacher required the whole group to report all finished at the end of the first activity.
The following observation is indicative of most classroom environments, not just developing collaborative environments.

7D - In an attempt to get students clear on the methods the teacher requires that they fully express all facets of their working and solutions.

'Normality', which can be overlooked, is quite common in our classroom and easily observed. The next two observations contain quite a deal of significant information.

5C - By leading the students, either in person or with material tasks, the proximal 'zone' is stretched further for each student and ultimately what was once out of reach is reached. Working ahead of themselves is therefore very Vygotskian providing they are working in groups. The collective energy provides considerable proximal development for each individual student.

7D - There was a lot of group work and discussion going on but so much was difficult for so many of the students that the teacher was involved in the discussion almost continuously, that is, strong peer / adult interactions working in the proximal 'zone'. The duration of this process indicates that many of the students were only capable of success when assisted but were unable to maintain their success when trying the problems on their own.

That "instruction must lead development" (Vygotsky, 1987, p. 206) is a fundamental requirement for a Vygotskian approach to learning and teaching. Working together enhances development as each student has potentially many instructors. Multiple interactions, whether one is involved personally or not, enrich the learning environment however even a classwide 'zone of proximal development' has its functional limitations and reduced performance once assistance is removed is one of the known limitations observed in this study.

(a) Discussion / Explanation
Observations from this category in the second month, regarding our skills in discussing and explaining our work, are much the same as those made in Month 1.

The following week 7 observations reflect a similar occurrence seen in week 5.
7D - The teacher posed a special challenge activity and one student gave a solution but the class discussion did not lead to acceptance of the solution and the resulting debate led to much confusion.
7S - Lengthy teacher led discussion results in fairly low levels of student response.

If students' prior knowledge and actual developmental levels in regards to a concept are sufficiently diverse then consensus is unlikely and confusion the probable outcome. Such outcomes are unlikely to result in any sense of community or 'taken-as-shared' knowledge. Other week 7 observations from this category show the alternative techniques we employ to encourage concept development. A stronger message represented in the observations is how student discussion emerged as a significant trait of our learning environment this month. Discussion which allowed us to move "from an environment in which students are totally dependent on the teacher to one in which students assume more responsibility for validating their own thinking" (NCTM, 1989, p. 79), thereby establishing "an atmosphere of mutual respect" (NCTM, 1989, p. 69). This was observed in student discussions of their homework and associated errors, and in discussions about answers as the additional observations below reflect.

6S - The students discussed the solutions within their own groups as the answers were given.
7S - The students were very vocal when the class was discussing the solutions to the mental questions. The more difficult questions were the focus of considerable discussion which involved many students explaining their solutions to everyone else.

It was further observed in discussions related to activities as the following observation highlights. Each of these observations is indicative of a very proximal learning environment.

7S - The groups are involved in a lot of discussion as they encounter new and difficult activities.

Student confidence in putting forward their ideas and explanations was observed in week 5 and in additional observations such as the following.

5S - The students are quite happy to comment on each other's work and modify it if need be.
This was another positive sign of the developing collaborative peer interactive classroom learning environment since "giving explanations requires a greater depth of understanding that goes beyond that required merely to state an answer" (Artzt and Newman, 1990, p. 449).

The students' willingness to dispute their work indicates their confidence to question each other and ultimately their teacher and their text, which they found to be in error once or twice as the observations for this category from week 7 show.

All these discussions and explanations provided the students with "evaluative feedback from their peers and their teacher to help them identify gaps in their own understanding" (Vaccc, 1993 p. 225) and gave each student the opportunity to adjust their "understanding and interpretation of phenomena" (AEC, 1990, p. 19).

Teacher confidence in allowing time for explanations is indicated in observations for this category from week 7, which also highlight the need for proper and comprehensive consolidation of tasks and activities.

All of these observations encapsulate "the role of students in shaping classroom events" (Cooney and Hirsch, 1990).

Other observations from this category indicate my perception of the good rapport I have with the students and also how many of their queries have been reduced to asking about procedural matters, with other issues being addressed within the groups.

One danger of which the teacher needed to be aware is indicated in this next observation.

5C - The teacher must be careful not to stifle debates or discussion when calling the whole class to order.

Once 'order' is restored and consensus summary discussions commence the teacher must remain open to all possible responses. "Teachers must be willing to entertain suggestions from students and suspend judgment about their ideas" (NCTM, 1989, p. 245) thereby "remaining open to creative student solutions" (Lochhead, 1992, p. 551). I accepted "all answers and solutions in a completely non-evaluative way" (Cobb et al., 1991a, p. 160) as the following observation highlights.
7C - The teacher often agrees with the students' incorrect responses or at least does not reject them, so as to prompt the other students into responding or commenting thereby creating a need for correction or adjustment or explanation among the students.

"Explaining something to a peer usually leads to seeing things more clearly and often to spotting inconsistencies in one's own thoughts - a process which provides a wonderful opportunity for learning" (von Glasersfeld, 1993, p. 31; AEC, 1990, p. 19). That the students in our collaborative peer interactive classroom learning environment had such opportunities is evidenced by this observation. One further observation, presented below, details another interesting development from this month.

7S - The students present results to activities on the board and the others discuss and negotiate the final solutions. Some just sit and listen.

Those who just sit and listen may well be busy learning. A collaborative learning environment provides a situation in which the students can still enhance their learning through a form of passivity which involves actively listening to others.

"Students can benefit from observing the interaction in the group, not only by actively interacting themselves" (Webb, 1991, p. 377). Monitoring or listening can be an active form of participation.

"The 'monitoring' feature of cooperative problem solving is often more productive than individual problem solving" (Kroll et al., 1992, p. 621). Thus the students had emerged into a new stage of discourse in their collaborative peer interactive classroom learning environment.

(b) Tasks
The observations from this category indicate how the complexity and difficulty of the work in first year high school is beginning to make an impact. An interesting facet of these observations includes how the teacher asks the students to define the terms and steps involved in an activity to further clarify the tasks for the class. Thus we are reaching back over the group and individual proximal 'zones' within the classwide 'zone of proximal development'. If the students are still uncertain about the activity the tasks are modified and brought within the reach of all students.
By keeping tasks within the proximal level we "enhance the potential development" (Vygotsky, 1987, p. 171-172) of each student. This is how a teacher identifies a "zone range within which to focus instruction" (Tudge, 1992, p. 1365).

Another interesting facet of these observations was how delving deeper into our first year high school work involved greater amounts of teacher explanation as this next observation illustrates.

6D - When the reading level of the text is too high and the interpretation is difficult the teacher is required to explain things.

Is this the reason behind increased teacher explanation? The mathematics we are studying in our course, Algebra mainly, now frequently extends concepts beyond the students' prior knowledge levels or requires connections to areas of prior knowledge which the student does not initially associate with these newer concepts. This is just another facet of the teacher's role. Frequently, as noted in the observations, this involves giving additional examples, working examples through with the students and reinforcing key steps in the process. New work still tends to delay some students more than others. Some stop thinking and just copy the examples which can be a problem in mentoring or peer interactive groups. However, interaction should be a two-way process and thus the students should expect to have to help others or at least re-explain to their mentor or peer what the process involves. Such practices exist in a collaborative environment to reduce the amount of simple copying and the amount of repetitive non-thinking processing which results in different activities and their associated concepts blurring together in the students' mind.

(c) Noise
The observations from this category re-iterate the previously established work pattern. Given a task the students noisily discuss how to do it, then quietly do it, then noisily discuss their solutions. Exceptions to this were: easy tasks - all noise, as the following observation shows, and difficult task - mostly quiet.

6S - The work is always chatty and no silent phase is observed in doing this activity.
This next observation illustrates the role of noise in group work.

5S - A mental session incorporated a 60 second block at the end for group comparison of answers. Very noisy collaboration.

Talk is noisy! Teachers working in collaborative peer interactive classroom learning environments get used to this and come to recognise that "most group work noise is 'productive' noise" (EDWA, 1984, p. 49-50).

(d) Behaviour
The observations from this category reflect the student behaviours noted during Month 2. They show that the students still need reminding to work in their groups, that there were things the teacher can do to enhance discussion, such as streamlining procedures or introducing time limits, however leaving the room at one stage produces no discernible behaviour change! Typically, the students are relaxed at the end of a week when they know they have the next week off on camp. One informative observation from this category relates to the time limit for continuous work. Future lessons should ensure that the lesson time is broken into activities which require shorter periods of time to complete.

(e) Help
The observations from this category illustrate my endeavour to service every need for help within the class. This is approached with the ideal of helping them to do and understand or learn rather than help by doing it for them. The observations illustrate ways in which I endeavoured to do this. Frequently the teacher must be the bridge or link across the 'zones' within the classwide 'zone of proximal development'.

This notion is further illustrated by the two additional observations below.

6D - The further we get into the term and the topics the more the students require help with new concepts.

7S - A student asked a question about work we had not yet done but the teacher addressed this within the context of known work and thereby placed the problem within the student's potential. A solution was negotiated as a result.
Working in the proximal 'zone' ensures that instruction is leading development.

(f) Homework
The observation from this category is included to show how I have made improvements to our class practices to enhance the value of activities such as the completion of homework. The students have responded well to such changes.

(g) Month review - Group Work ethic / process
Reviewing the Group Work ethic / process section for this month shows the implementation of several initiatives designed to enhance the development of our collaborative peer interactive classroom learning environment. The use of visualisation and physical representations broaden the potential for concept understanding in our work. Social and group work norms are being further refined and modelling of these skills, by the teacher and by the students, is increasing. Many processes observed this month mirror those seen the previous month while others, such as giving help and the use of multiple interactions, extend the students' skills and refine their group work techniques. Discussion and explanation are very effective learning tools, with students willing to debate and justify their mathematical thinking. Passivity, in the form of active listening, is evident in this month's observations, although some passivity is laziness and this month the teacher is still reminding groups about being on task and working as a team. The increasing difficulty of the new high school level of work is becoming apparent this month. This facilitates the growth in our group work skills - a matter of necessity it seems. Observations further illustrate the in-class functioning of the classwide model for the 'zone of proximal development'. These observations are very pleasing given the strong Vygotskian focus of this implementation. The teacher is seen to be giving more explanations and, at the same time, endeavouring to reduce the quantity of instruction and the time given to such talk. This is a winsome, lose-some situation for the time saved by streamlining instructions is consumed by the need to give greater amounts of explanation. The benefit in evidence this month is in reduced talk to the class, allowing time for increased discussion among the groups. The work pattern, established in the first month, remains functional
throughout Month 2 and we now know that continuous work periods need to be less than 30 minutes in duration to be effective to learning. Teacher help is improving, due to the factors described above, and the value of homework is being enhanced over previous efforts.

By the end of this second month we see how our collaborative peer interactive classroom learning environment has improved from Month 1 and how changes and improvements made in Month 2 have benefited all of the students and enriched our environment.

The environment - group size and effect.
Observations from this category, focusing on our work environment this month, show how new work can be set ahead of the consolidation of old work when a collaborative environment is in place. This is because collectively, the students are able to assist each other, work in their proximal 'zones', and use the new concepts to further clarify, consolidate and then extend the application of the old concepts.

"Instruction of the pupil in new concepts is not only possible but may actually be the source for a higher form of development of the child's own concepts, particularly those that have developed in the child prior to conscious instruction" (Vygotsky, 1987, p. 171-2, italics in original). Coming to terms with new work is often simply a matter of discovering what old work can do.

Collectively, the students can reach their potential developmental level as they receive instruction in, or study examples of, new concepts in a topic.
This "goes to the heart of the schooling process" (Boomer, 1986, p. 4) as the teacher endeavours to link the 'scientific' concepts they are presenting through instruction to the students' 'everyday' concepts.

New 'scientific' concepts reside at the students' potential developmental level on the fringe of their proximal 'zone'. By working together, the students are able to link their previous or 'everyday' conceptions, through the study of problems within their proximal 'zones', to the new or 'scientific' concepts being presented by the instruction and thus raise their actual developmental level.

"The Vygotskian teacher will devise various ways of achieving this" for they will "put a good deal of energy and teaching strategy into closing the gap between the everyday and scientific concepts" (Boomer, 1986, p. 4).
Having the students work collaboratively allows them to develop 'scientific' concepts using the understanding they already have from their own, or their peers, 'everyday' concepts.

By increasing their skill and ability, in regard to solving problems using the new concepts, the students are shifting their proximal 'zones' to include these new concepts and consequently increasing their knowledge base.

"The level of development of scientific concepts forms a zone of proximal possibilities for the development of everyday concepts" (Vygotsky, 1987, p. 169). As the students develop their abilities by working with these new, and their old, concepts the new becomes old and the old becomes new.

"What lies in the zone of proximal development at one stage is realised and moves to the level of actual development" (Vygotsky, 1987, p. 211). These concepts move in opposite directions and operate as attractors and reinforcers of each other. Thus it is important in the learning and teaching environment that instruction leads development as Vygotsky explained. "Results indicate that the accumulation of knowledge leads directly to an increase in the level of scientific thinking and that this, in turn, influences the development of spontaneous thinking. This demonstrates the leading role of instruction in the development of the school child" (Vygotsky, 1987, p. 168).

When the teacher takes the work beyond the students' proximal 'zone' the students may lose sight of the goal of the work. This should happen, for the teacher needs to determine the potential and the limits of the topics being studied.

"Interaction should be within the child's zone of proximal development" (Tudge, 1992, p. 1365) for "instruction plays a leading role in the development of the child" (Vygotsky, 1987, p. 168).

Careful discussion can, at times, bring the students successfully through to points well beyond their proximal level. This is the exception and not the norm in classrooms however, even in a collaborative peer interactive classroom such as ours.

The final section of observations focusing on our working environment delineates the new group arrangements put into place during week 7 when half of the class went away on a camp. The 'spy' request led to the Buddy reports which are reviewed in the specific events section at the end of the month. Some of the predictions or
thoughts on how these groups and their new members would function are examined in the next section.

Observations:
The observations for this category, made during week 7, focus on the new 'camp' groups in place for just this week. Camp Group 3 have the best group work approach and Camp Group 4 are working reasonably well also. Camp Group 6 is not working well as a group. However, this group is bringing their new member (from Group 5) out of her shell, as I had hoped they would. Group 4 are behaving as normal and their new member (from Group 1) is maintaining her personal work ethic during this week. Although Group 3 are quieter than usual, they are working well and their new member (from Group 2) may be helping in this regard.

Figure 10
Group 2: Amanda, Denise and Emma
Student support and criticism of each other and the teacher.

The value of good support and effective means of criticism should not be underestimated in a collaborative learning environment. In Month 2, as in Month 1, an observation from this category notes the teacher supporting a student and helping her re-develop her solution. This is an example of the teacher modelling team building skills. Doing so allows all students to gain confidence in group work just as the one who is helped in this way gains confidence. While the 'safety in numbers' motivation may be behind wanting to do a test in groups, not being able to do so is detracting from our collaborative endeavours.

The reality of our situation however was that "assessment practices in secondary schools require students to demonstrate their individual competence" (EDWA, 1984, p. 7-9).

The students use of the board to form alternative groups and work on their problems did not support the rest of the class and had a negative impact on our social norms. Future use of the board would need to avoid this habit and instead ensure that this medium was used as a communication device for the whole class. A subdued work environment may be the result of difficult tasks or similar internal effects (moody teacher, fall out of friends), or may result from external influences such as tiredness from camps or the weekend, or perhaps a previous lesson was suppressive of activity.

"No matter how good a job a teacher does at creating a cooperative community within his or her own classroom, much of this work can be undone when students move to classes with competitive or alienating environments" (Graves, 1992, p. 63).

On the positive side, observations report, yet again, the willingness of the students to engage in disputes, discussions, problem analyses and corrections. The following observation notes this very point.

7S - Student solutions are analysed, discussed and if necessary corrected by the whole class.

Our classroom norms of "seeking clarification in discussion, being willing to talk about ideas, listening and responding to other students’ ideas and building on these ideas to further understanding" (Vacc, 1993, p. 225) were functioning very successfully. This was not always the case. In the observations from this category of the groups working, only one group, Group 3, seemed to be on task during a lesson. Was there a problem with the task or had the students simply not settled.
down to work yet? My comment about 'bonus marks' for good work, noted in the observations, was meant to motivate the other groups into action. It didn't work! Later observations from this category indicate that most students were working individually. This is necessary as major assessments are worked individually, thus making it critical that students have some individual time when working in groups. Each student has to learn to cope on their own while at the same time having the advantage of working collaboratively whenever they need to. There are certainly times in our lessons when we do not need to work collaboratively. Working individually also reflects reverse movement within our 'zone of proximal development'. The 'zone' is a dynamic entity that allows for the two-way movement of development and moving back to one's actual developmental level, and working individually reflects this process. The tasks will still extend the students into their proximal 'zone', and thus collaboration is achieved through the interaction of the student with their subject materials.

The observations from this category reflect how I used the impending return of the test results as an extrinsic motivator to get the students to work hard and earn this 'reward'. Such things do work, as teachers are aware. "Certain rewards are almost always effective" (Chance, 1993, p. 789). Another support observation, made this month and presented below, shows how I used the students' ideas to re-build examples and concepts when working on an activity.

7S - The teacher led a discussion of the next activity, and the students asked for several points to be re-explained. The teacher re-developed the ideas using student contributed answers and solutions.

I also used student solutions to emphasise and highlight the important outcomes of activities as this next observation shows.

7S - When a student gives a solution the teacher highlights the points which everyone needs to follow in order to understand the concept.
Questioning.
Coupled to the important roles of support and criticism is the role of questioning within our collaborative peer interactive classroom learning environment. Observations on this theme from Month 2 raise several significant points of interest. Monitoring another groups discussions is an active form of participation in the classroom.
"The 'monitoring' feature of cooperative problem solving is often more productive than individual problem solving" (Kroll et al., 1992, p. 621) and "students can benefit from observing the interactions of a group" (Webb, 1991, p. 377). Having the students present their solutions to the class is an even more active form of participation and the next, and possibly better, step up from having the teacher use student solutions for explanations. Both techniques give clear and rapid feedback on solutions and methods.
The observation below illustrates how I gave several examples, as per the students' needs, to develop their understanding.

5S - The students continue to ask for clarifying examples. The teacher offers the same in many, varied and practical ways. Some are clear on it, others are thinking still.

Other observations from this category point to the development of class consensus based on summaries of our endeavours. We have well established collaborative norms and this "makes possible the negotiation of mathematical meaning" (Lo and Wheatley, 1994, p. 145). Leading the students in a class discussion of our methods, solutions and findings develops our communal 'taken-as-shared' understandings.
The students "come to a task or problem with their own subjective ways of making sense of it. If they then discuss their differing viewpoints, shared understanding may be attained" (Tudge, 1992, p. 1365). "The teacher will have to account for any variation and be able to act on this difference in understanding" (Pirie and Kieren, 1992, p. 508). Observations of my doing this are made in both week 5 and week 7. As a class we are engaged in intersubjectivity, "a process of interchange, a dynamic during which meanings are chosen from a repertoire of social language and experience" (Solomon, 1994, p. 15). "Intersubjectivity emphasises that understanding happens between people" (Rogoff, 1990, p. 66). We are also "constructing our collective and individual knowledge" (Davis et al., 1990, p. 3) and understandings based on our consensus discussions.
In the course of class discussions I deliberately endeavour to engage all students, an important action as all teachers would realise.

Intersubjectivity was also achievable when moving around the room interacting with the groups. Moving around the room gives me a broad overview of the progress within an activity as I listen to the groups work and it allows for the assessments and actions eluded to in the observations for this category. "Teachers need to listen to students and utilise what they learn from listening" (Lacampagne, 1993).

I can then address problems as they arise in our collaborative environment. It is not just the teacher who can answer student questions as the observations from this category show. The text and especially one's group can also answer student questions and help the students when they get stuck. The teacher needs to highlight this from time to time.

The observations from this category also show that I "accepted all answers and solutions in a completely non-evaluative way" (Cobb et al., 1991a, p. 160) which illustrates how I valued student input and encouraged all students to volunteer solutions. This was, of course, accompanied by non-threatening criticism when incorrect solutions were put forward. Our collaborative learning environment was "an effective technique for correcting errors" (Amigues, 1990, p. 41) for it recognised that "using mistakes to effect learning was better than merely correcting them, and verbal interaction is a good way to encourage this" (Duffin, 1986, p. 11). Our environment endeavoured to have students "feel safe to make and learn from mistakes" (Duren and Cherrington, 1992, p. 80). "To learn from a challenge or conflict, the student must recognise it, see errors as a useful source of feedback" (CC, 1998, p. 207). Once this was the case, students were encouraged to check and correct each others work in a "spirit of helpful collaboration" (NCTM, 1989, p. 169).

Other observations in this section point to the need for the work we do to have a future purpose which is external to the here and now of our class work. The students are shown examples of the use of their new skills in higher level mathematics courses which is one way this can be done. The observations for this category show that I am still reminding the students of the importance of helping their group members.
The two extra observations below highlight this.

6S - The questions asked of the teacher were referred back to the group for resolution.
7C - The teacher answered a student's question and expressed surprise that no one in the group knew the answer. The student admitted not asking the group.

I was also reminding some group members to ask their group for help as these next observations show.

6S - Questions which the teacher won't answer because the group should but which that group can't answer are put to the whole class for solution.
7S - The teacher directed a student's question to the whole class for an answer. Several students gave the correct response.
7S - The teacher asked the class to answer a student's question.

"Giving and receiving help" (Webb and Farviar, 1994, p. 372) are important skills for collaborative groups.
Other observations from this category show how some students are still teacher-centred when it comes to questions.
These few students had not yet "assumed responsibility for their learning by being accountable to themselves and others" (Behounek et al., 1988, p. 12). However most, by now, were focused on their groups as the initial question/answer source.
Thus our environment had evolved into a social milieu of activity which held opportunities for all participants for, as Newman and Holzman told us, "creating a classroom environment that allows the social nature of learning to be expressed leads to increased learning" (1993, p. 70).

Teacher comments and observations.
The Month 1 section 'teachers use of student features' became 'teachers comments and observations' in Month 2.
One observation from this category offers me a warning to ensure that all students are treated equally within our environment. My understanding of the nature of our learning and teaching environment is being enhanced through my interactions with the students.
"As the students are learning mathematics, the teacher is learning about mathematics, learning, teaching, and about the mathematical thinking of their students" (Simon, 1995, p. 141).
At the same time my control procedures are observed with particular notice being made of my attempts to restrict unproductive debate, by providing better guidance during discussions, and also my use of a 'loud' voice, which I direct at one student but intend to be over heard by many, to guide behaviour and work practices.

It is also observed that I exhibited a fairly negative attitude towards some students. "Negative attitudes inhibit learning" (Cockcroft, 1982, p. 101). By highlighting these features of my interactions with students I am informing myself of possible weaknesses in my practices and alerting myself about aspects of my behaviour which could be improved to avoid damaging the relationships within, and hence the overall tone of, our collaborative peer interactive classroom learning environment. In terms of maintaining or improving our environment one observation from this category notes that I avoided undermining our collaborative learning environment structures by guiding students to their group to get the help they needed. The power of the group to deal with their questions was honoured and preserved by these actions on my part. These group work norms and "small-group skills are vital to the success of cooperative learning" (Johnson and Johnson, 1990, p. 30) and vital to the on-going development of our collaborative peer interactive classroom learning environment.

A positive indicator of our growth in this regard is the observation from this category which highlights how the students are more able to ask questions now that the teacher is free to move around the room. I am able to ask more questions of the students, confer with them on their methods and direct their efforts toward improving their groups learning.

When interacting with the students, either in groups or with individuals, the teacher will be asking questions which may prompt the student to clarify, to predict, to develop further, to look for alternatives. By asking these questions the teacher models the questions that the students will ask later, either of themselves when refining their work, or of others during a sharing time (Edmunds and Stoessiger, 1990, p. 31).

Another observation from this category celebrates the pleasure a student finds when she expresses an idea publicly and gains wide spread support for the idea from her peers. This occurrence boosts that student's self confidence, a winning benefit of working in our collaborative and supportive classroom learning environment.
Paralleling this were further examples, in the form of the observations reported below, of my use of students' work, methods, ideas and solutions, which also aimed to build confidence in the students and in our learning environment.

6S - The teacher used the students to present solutions to the class as the focus for discussion of the problems.
6S - The teacher used a student's solution as the basis for corrections to the class.
6S - The teacher used students' answers for all solution development, often collecting several responses to make the points clearer.
7S - The teacher used a student's correct method to demonstrate the solution to others.
7S - The teacher developed or illustrated a concept using the students' responses and answers.

These actions on my part contributed to the improvement of our collaborative learning environment and hence assisted the students to improve their learning outcomes. "The teacher facilitates the students' mathematical development by subtly highlighting selected aspects of their mathematical contributions" (Yackel et al., 1990, p. 35).

Tape recorder.
There were no significant observations for this category, recorded during the second month, to do with the ethnographic methodology of the study. The tape recorder had become just another piece of furniture and the research procedures were transparent to our collaborative classroom practices.

Disconfirming Evidence
During Month 2 several instances of disconfirming evidence were recorded and noted in the observations, vignettes and associated narratives. This evidence is further highlighted below, in summary form, to exemplify possible limitations in the implementation. Limitations are discussed in Chapter 5.
• teacher has to remind students about collaborative processes
• 6S – the teacher still needs to emphasise the group focus idea to enhance sharing
• the students still require assistance in utilising their group work skills
• the students still need reminding to work in their groups
• the teacher is still reminding the students of the importance of helping their group members
• 6S – the questions asked of the teacher were referred back to the group for resolution
• 7C – the teacher answered a student's question and expressed surprise that no one in the group knew the answer. The student admitted not asking her group for help
• the students are still teacher-centred when it comes to questions
• 5G – should use student demonstrations more often
• different teaching approaches work for some, but not all, of the students
• students remain loyal to their prior knowledge – accepting a new concept is a slow process
• the students suffer from reduced performance once assistance is removed – this is a functional limitation of the 'zone of proximal development'
• 7D – debate can lead to confusion
• 7S – lengthy teacher led discussion results in fairly low levels of student response
• such outcomes, (the above two observations), are unlikely to result in any sense of community or 'taken-as-shared' knowledge
• there is a need for proper and comprehensive consolidation of tasks and activities
• the complexity and difficulty of the work is beginning to make an impact
• delving deeper into our work involved greater amounts of teacher explanation
• the teacher could do more to enhance discussion
• lesson time must be broken into activities which require short periods of time to do
• Camp Group 6 is not working well
• wanting to do tests in groups, and not being able to, is detracting from our collaborative endeavours
• the use of the board by students had a negative impact on our social norms
• at one stage, observations indicated that many students were working individually
• the work we do needs to have a visible, known, future purpose
• the teacher must ensure that all students are treated equally
• the teacher exhibited a fairly negative attitude towards some students.

Thus as the second month drew to a close, the classroom observations reflected both strong growth in the nature of our collaborative peer interactive classroom learning environment and continuing support for our environment's structure. We were still developing several collaborative learning norms and we were reaping the benefits of the norms we had established already. Next month would see us complete our first school term in this structure.

In the next section, we will examine the specific events from Month 2 which were the second MCI classroom environment survey, the results of the Mid-Term 1 test, a report on group work in other subjects and the Buddy reports from the first 'camp' week (week 7).
My Class Inventory (MCI #2) - week 6

The first specific event to report on for Month 2 is the second classroom learning environment questionnaire, the My Classroom Inventory or MCI. From the data collected through MCI 2, shown in Table 8 overleaf, class and group charts were produced and these are shown, on the following pages, as Figures 11 and 12.

These were analysed to determine future actions aimed at further developing our collaborative peer interactive classroom learning environment along the lines we desired and within our theoretical and practical guidelines. The charts were presented to the students and the outcomes were discussed in class. A transcription of this discussion is presented in Appendix 3.2.

The transcript is quite brief as there was not much time in the lesson to discuss these results. From the class perspective the students had high levels of satisfaction and cohesiveness and yet they still wanted more of these attributes. The levels of friction and difficulty were low with the latter being almost exactly at the right level for the students while they preferred less friction. The competitiveness within the classroom was still too high for the students' liking.

In comparison with last month I was correct to say to the students, in the transcript, that things had improved between the first and second MCI results. Each of the attributes measured by the MCI had improved from Month 1 to Month 2. The gap between the actual measure and the preferred measure had decreased on each scale, thus our environment was evolving along the lines we desired, and the adjustments suggested by the first MCI, which we had worked on in the intervening time, appeared to have been successful.

For the Satisfaction attribute the differences between the two measures (actual and preferred) decreased by 0.1 on the scale. The actual level of satisfaction fell 0.2 but the preferred level fell 0.3. This reflected our discussions about just what was achievable in a classroom as far as satisfaction was concerned. To be perfectly satisfied the students admitted that not having to come to school would rate fairly high. As this was not an option they agreed that the level of satisfaction within our class was very high as the MCI results show. The high level of Satisfaction reflected the students' enjoyment of their class, as a place to work in, and of the work they did. At least we had moved closer to their 'perfect' scenario over the past month.
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Figure 11
MCI 2 Class Graph
Figure 12
MCI 2 Group graphs
The Friction attribute also improved with a fall of 0.4 in the actual measure for this scale. This reflected higher levels of agreement among the students and indicated that they were getting on better compared to the previous measure. We had made gains in this attribute during Month 2.

For the Difficulty attribute the students' preferred level fell another 0.5. That is they wanted the class work to be even less difficult compared to Month 1. They had lost some of the confidence in their ability to do the work - or had they? The actual level of difficulty fell 0.8 for the month which brought us even closer to our desired level. The difficulty level of the work and our belief in our ability to do that work were well matched.

Competitiveness remained our least 'controlled' attribute. The difference between what it was and what we want it to be was still quite large but this month the gap had fallen by 0.6 so we had made excellent gains on this attribute. The actual level of competitiveness fell by 0.8, the largest 'gain' of all the attributes. Given that the Mid-Term 1 test was only a couple of days away these gains were quite significant. It was not yet as good as we wanted but we had made substantial progress in the face of mounting pressure (the test was soon!) on this attribute.

We did even better on Cohesiveness. As impossible as that may seem we trimmed a massive 1.3 off the difference between actual and preferred on this attribute. Our preferred level fell 0.8, reflecting our more realistic perception of what we can achieve, and our actual level rose 0.5, clearly indicating the improvements in our friendships and our support for each other in our groups. Thus over this past month the class made gains on the Satisfaction, Friction and Difficulty attributes and it made significant gains in the attributes of Competitiveness and Cohesiveness. There was less competition and we worked better together. These results represented MAJOR improvements in our developing collaborative peer interactive classroom learning environment and they reflected the success of this implementation.

Group 1's results improved on the Friction and Cohesiveness attributes during Month 2. They were a little less satisfied than in Month 1 but the competitiveness had reduced. Group 2's preferred level of satisfaction fell during Month 2 but still matched their actual level. Friction had increased slightly during Month 2 as had Competitiveness while Difficulty fell slightly. However it was in the Cohesiveness attribute that the biggest change was evident. Group 2 had been working very hard at improving their group work and managed to succeed, as this measure shows. In
fact they succeeded too well and registered a preference for slightly less Cohesiveness in future. Group 3 reined in the level of Competitiveness substantially over the second month and they also significantly improved their Cohesiveness. Satisfaction and Difficulty remained relatively static, however Friction increased during this time. Group 3 will need to monitor this next month.

Group 4 managed to increase their Satisfaction, lower their level of Friction and reduce the amount of Competitiveness although they would have preferred the actual level to fall even further. The Difficulty level was a better match for them in the second month and their Cohesiveness improved but they would have preferred this to go even higher. These results were a strong improvement for Group 4. They should have been proud of what they had achieved. Group 5 were more Satisfied, had less Friction and had become more Cohesive since the previous survey but their Competitiveness had increased dramatically. Their preferred level remained the same but their actual level had risen by 2.0. My assessment of this related to the personalities of this group. Two of these three students were 'test-phobic' and the looming Mid-Term 1 test had raised the levels of Competitiveness in this group. They were working better together, as the improvements in Friction and Cohesiveness indicated so it had to be the test. I hoped that they could control the level of Competitiveness at other times. Group 6 improved in every attribute and yet in Cohesiveness they still wanted more. They had set themselves a challenging goal.

Actions which each group can take to further enhance their collaboration are evident from their own charts as analysed above. For the class, I must now both celebrate the success of the improvements implemented since Month 1 and accept the challenge of finding ways to further improve our collaborative peer interactive classroom learning environment over the coming month. The actual level of Competition remains too high for the class and this must be addressed over the coming weeks. Regrettably there are an increasing number of assessments looming and this will make improvement in this attribute difficult. I will endeavour to support groups who support their members and thus attempt to maintain high levels of success for all students. This may assist in narrowing the Competitiveness gap. Friction can be further improved if I mediate more effectively in disagreements and this may also have an impact on the actual level of Competitiveness. I anticipate the Difficulty attribute will worsen as the course work progresses. We shall see. As for the attributes of Satisfaction and Cohesiveness,
both currently at very high levels, I shall endeavour to maintain the students’ enjoyment level in our class and I shall continue to strongly encourage the groups to work together as a team for this will enhance all aspects of our collaborative peer interactive classroom learning environment.

**Mid-Term 1 test results - week 6**

Table 9 presents the individual and group average results for the Mid-Term 1 test.

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This test was completed by each student individually. Such assessments were carried out in this way as a matter of school policy. The results were varied ranging from 42.1% to 89.5% with a class average of 69.8%. These reflect the heterogeneous nature of the class and the diversity of the students' backgrounds. The test covered the first three topics on geometric shapes, Integers and the Rule of Order of Operations. The group averages reflected the earlier observations that I had made particularly with regards to the mathematical ability of Groups 1 and 4. As this was the first formal assessment of the students' mathematical ability, this test served as an indicator for future performance. As the test did not assess any algebraic skills, often a strong discriminator for this age group, and we were only six weeks into the year, these results were fairly vague indicators at best.

Group work in other classes - week 7. (see also Month 3)

During the first 'camp' week, (week 7), I surveyed the students present as to which of their other classes / subjects utilised some form of group work. This was a teacher awareness raising exercise after all "no matter how good a job a teacher does at creating a cooperative community within his or her own classroom, much of this work can be undone when students move to classes with competitive or alienating environments" (Graves, 1992, p. 63). Appendix 3.3 details the students' responses.

Clearly these responses depended greatly on each student's understanding and personal definition of group work. The most significant impression I gained from this was that there was a lot more group work happening in other subjects within my school about which I was originally unaware. Theatre Arts (Drama) seemed to nominate itself, given the nature of drama and acting, and Media Studies also presented itself as a team-based pursuit. For me, English (5/12) and Science (7/12), while not overwhelming, were a surprise, as none of these teachers had ever extolled the virtues of collaborative learning. Computer Studies also surprised as I imagined this as a very individual oriented subject. This data encouraged me to believe that by working in, and seeing, other collaborative learning environments the students would find the process of developing a collaborative peer interactive classroom learning environment less of an isolated event occurring only in their mathematics class. I now also believed that the rest of the world was not completely against us in our quest to develop a collaborative peer interactive classroom learning environment.
Buddy Reports - week 7

The final specific event to report on for Month 2 is the Buddy reports. The students who were placed into other groups for the 'camp' week (week 7) were asked to write a report for me on the collaborative practices of the group they joined. Their reports are presented in Appendix 3.4.

I believe the quality of these reports to be outstanding, making the exercise quite worthwhile. The frankness and honesty results from the secrecy of the process. The other students had no idea their group work skills were being monitored. It is not my place to interpret these reports for they present an alternative perspective on the groups and on our collaborative peer interactive classroom learning environment. I will make one observation though. After seven weeks of working in a collaborative environment these students reported about the groups they had joined in a manner which suggests they had a collaborative mind set. Things are that way because that is the way things are. Strong evidence of the success of this implementation.

MONTHLY REVIEW #3: April - Weeks 8 to 10 (inc)

This next section presents the observational data collected during weeks 8, 9, and 10 of the implementation, Month 3, which takes us to the end of the first school term. The observational data referred to is presented in Appendix 4. The narrative is delineated into the categories described in Table 1, and is similar in structure to Month 1. The category Group Work ethic / process is further divided into additional criteria as discussed earlier. Following the narrative for the observational data, the narrative for the data arising from specific events is presented. For Month 3, these include the second set of reports on group work in other subjects, the second (week 8) and third (week 10) sets of Buddy reports, the group photographs which are spread throughout Chapter 4, a report on the first video review of a lesson, the results of the End of Term 1 test, a report on the observation of the class by a research colleague and the results of the first Classroom Learning Environment Survey, or CLES, a constructivist-based learning environment instrument. Each reflective narrative examines and highlights key points from the observed data and discusses the progress of the implementation from the context of that category.

A reminder that raw observational data is presented in Helvetica font, vignettes are presented in Bookman font, and the thesis commentary or report remains in normal Times font.
Assessment.
The first observation from this category exemplified the use of extrinsic motivators that encouraged student motivation. I did not like the level of enthusiasm or competitiveness this generated and discarded the technique shortly after introducing it. When the students next asked about 'the points' I suggested they participate because of their own need to know. "The practical experience of many teachers suggests that after a while students no longer need external incentives to induce them to work together effectively" (Graves, 1991, p. 78). Homework was still being carefully monitored, a practice enhanced last month, however some homework expectations exceeded the students' capacity to complete.

Group Work ethic / process.
The observations from this category point out that the students who remained during the second 'camp' week worked less effectively in their temporary groups than did the students who remained the week before. The students did show glimpses of good collaboration in this week as the following observations illustrate.

8C - While all groups were working well there was a lot of the 'class noise' type of discussion going on. Loud and multi voiced.
8C - Pleasant personal conversation occurred indicating a good personal rapport exists between the students and the teacher.

What is occurring in this 'camp' week is a decline in the students' activity and participation. As a consequence, I fill the silence with an excessive amount of teacher exposition. This illustrates "the role of the students in shaping classroom events" (Cooney and Hirsch, 1990). I was equally to blame for these non-constructivist behaviours. I had slipped back into "telling and describing" as distinct from "listening, questioning and probing for understanding" (Maher and Alston, 1990, p. 61). My old habits were never far away. "Even teachers who try to develop learning environments that feature rich interactive dialogue are prone to lead rather than to guide" (Voigt, 1985). The students had also lapsed with the following observation noting yet more poor group processes.

8D - The students were consulting with the teacher when troubled - told to consult with their group.
Other observations from this category point out poor helping skills and poor explaining skills. All was not lost however with these following observations detailing quite positive collaborative behaviours.

8S - Very good responses and consensus on the solutions discussed by the students in their groups. One group (Camp Group 5) got quite animated in it’s discussion.
8S - A different student contributes each answer.

Indeed, the observations from this category point to a quite dramatic turn around in group processes once the regular groups are reformed after the camps. Some excellent collaborative skills are observed including quite prolonged periods of group activity, discussing, collaborating and helping each other.

Over this three week period we can saw quite big swings in the level of collaborative activity. Other observations from this category focused on the increase in student interest in the classroom environment surveys. This related to the change from MCI to CLES. I gave advice as requested but was simply confirming the students' correct ideas. In the observation below I give an overview of our performance in these learning environment measures.

10S - The teacher commented that he thought that this area of group skill had improved in the groups, that is the students were much better now at monitoring questions and answers, agreeing and supporting each other or disagreeing and giving alternative responses.

(a) Discussion / Explanation
The second 'camp' week observations for this category showed a renewed teacher-centred focus by the students. Within groups, collaborative processes were still functioning and the students worked well when they were clear on task requirements as this next observation illustrates.

8S - The students discussed the solutions, correcting and questioning as they required.

Other observations from this category show how I let the students, in their groups, summarise the activities and problem solutions. In a collaborative peer interactive classroom learning environment such as ours I often endeavour to hand over the responsibility for task completion to the students, encouraging them to work and think collaboratively within their groups as well as individually.
In such a situation "the teacher appears to be more easily able to moderate the influence of the social behaviour on achieving the mathematical learning outcomes, a role closer to a Vygotskian approach" (Higgins, 1995, April, p. 9). When everyone had the same results there was no need for a class summary, as this next observation shows.

9S - The teacher did not summarise the class results as this would have devalued the student discussion and results.

This highlighted one of the benefits of a collaborative learning environment, namely that it "helps to minimise teacher dependency because children assume more responsibility for their learning by being accountable to themselves and others" (Behounek et al., 1988, p. 12). Two weeks after camp our collaborative discussion practices had been fully restored. Observations, like this next one below,

10D - Unusually low levels of interaction were evident during class discussion of the answers with only a few minor changes suggested.

reflect the notion of consensus among groups reducing the need for class consensus since the students shared the communal taken-as-shared knowledge and understanding of these concepts.

Collaborative activity can result from interaction with materials as well as interaction among peers as the observation describing the mathematics magazine illustrates.

(b) Background

The observations from this category highlight the significant levels of prior knowledge which the students hold about measurement and the metric system, most of which arise from the students' personal practical experiences.

"Building on and stimulating recall of prior experiences was essential for further development of concepts" (Clarke and Kessel, 1995, July). The observations illustrate how the students "model relationships from their own daily experiences" (CC, 1997, p. 194). Also illustrated by the observations from this category was the considerable knowledge the students had about non-metric systems of measurement. They gained this knowledge from their out of school, social, family experiences which show how the "students are gaining more experience of the wider community and of other school curriculum areas" (CC, 1997, p. 192). This supports the Vygotskian notion, of which social-constructivists are aware, that "prior knowledge
need not have been developed in class, it may have arisen in an out of class activity" (Bishop, 1995, July). Regardless of the origins, this topic showed that "students in any particular classroom will have much in common and will bring to the classroom a wide range of different experiences which should be valued and accommodated" (AEC, 1990, p. 17-18). Thus our learning outcomes were enhanced as a consequence of our sharing of this prior knowledge. "Learning results can be improved when students' preconceptions are activated both before and after the presentation of the new material" (Ali, 1991, p. 79-80).

The topic, measurement, presented us with the situation of having the course lagging behind the students' actual levels of development causing instruction to lag behind the development of the concepts. Thus we had a situation where the students' culturally and socially-developed 'everyday' concepts led the development of their instructionally-based 'scientific' concepts.

The observations from this category also show that prior knowledge does not always translate into ability to use the knowledge in the mathematics class.

However, the students were pleased to know that "prior knowledge had a more significant relationship with mathematics achievement than did intelligence" (Weinert et al., 1990, p. 467). Thus the topic became a quest to improve the students' abilities to apply the knowledge they held. A situation in which the "school instruction could re-direct the child's development toward the internalisation of the socio-historical knowledge of the culture in which the child grew up" (Oerter, 1992, p. 188). Further evidence of "the social nature of learning" (Newman and Holzman, 1993, p. 70).

(c) Tasks
The observations from this category show that after the camps, during which the students were present at school for only one of two weeks, there was a need to establish a common ground as to the content each half had addressed while at school. This restored a balance in our classroom-based taken-as-shared mathematical knowledge.

The observations also show my introduction of activities which allow the students to move flexibly within their proximal 'zones' either consolidating work or extending into new areas. This type of activity set caters for the dynamic nature of the students' 'zones of proximal development'. The collaborative environment retains the role of peer assistance for the times it is required. More of these types of activities are planned when topics are facilitated by such tasks.
Another observation from this category comments on the general good work ethic which the students demonstrated while doing a test. Also, as was the case in Month 2, I have further utilised visualisation and practical activities in our work to enhance a broader range of student understanding.

(d) Behaviour
The observation from this category reports on the respect and support that our environment has engendered in the students. An interesting report on the extra-curricula activity certainly held everyone's attention, even after the bell to end the lesson!

(e) Help
The observations for this category from week 8 reflect several positive aspects of the students helping each other in our collaborative peer interactive classroom learning environment. This help assists us to correct our methods, improve our solutions and clarify our understandings of the concepts we are studying. A Vygotskian environment using collaborative techniques to produce constructivist outcomes. It has all come together.

Then in week 9 we see the negative side of our environment with students operating in their own personal worlds not offering help to anyone else. Very 'anti-collaborative' behaviour, but this too passes and our observations from this category describe an active helping environment, although in one case, Group 4, this seems to have arisen out of necessity. As case of excessive teacher independence or perhaps excessive self responsibility. No! More likely a case of failing to pay attention to instructions!

The week 10 observations from this category give a specific account of students asking for help and students giving help - good work all round. Even I get in on the act, suggesting to students who still have concerns to speak up and seek help for now is a good time to get help. As the teacher I am expressing my support of, and faith in, the workings of our collaborative peer interactive classroom learning environment.
(f) **Month review - Group Work ethic / process**

Reviewing the Group Work ethic / process for this month shows that the temporary groups working during the second 'camp' week were less effective than those formed in 'camp' week one. I was also not happy with the examples of myself resorting to quite non-collaborative and non-constructivist practices, nor was I pleased with the examples of the students similarly abandoning their cooperative group work skills. Our environment revived once all the students returned to their normal groups and in fact embarked on quite an up-swing in terms of developing our collaborative skills. Several examples of collaborative skills were observed and I continued the use of practical and visual work to enhance concept development.

Positive developments this month focused on greater levels of autonomy for the students in our activities, while the development of taken-as-shared knowledge at the group level extinguished the need to develop class consensus. The strengths of the students' prior knowledge in some topics was especially evident in this month's observations. This month, as in Month 2, our observations highlighted the Vygotskian perspective on the interplay between a child's 'everyday' and 'scientific' concepts giving us a 'theory-in-action' situation in our implementation. Another development this month was the role of flexible activities, which allowed the students to situate themselves at any point within their 'zone of proximal development' so as to enhance their learning and their understanding of the concepts being studied. Student support of one another in our collaborative peer interactive classroom learning environment was again exemplified through several observations of instances of students seeking help and being helped.

By the end of this, our third month, we had endured several negative events - temporarily restructured groups, individual focused tests and lapses into past practices - to emerge with many new collaborative skills and a growing sense of community. We had all benefited from and enriched our collaborative peer interactive classroom learning environment.

**The environment - group size and effect.**

Observations focusing on our work environment this month began with details of the arrangements for the students at school during the second 'camp' week. I again asked the 'new' group members to 'spy' on their 'new' groups and this generated another set of Buddy reports which are reviewed in the specific events section at the end of this monthly review. Some of my predictions or thoughts on how these groups and their 'new' members would function are outlined in the next section titled Observations. There appeared to be some awareness of the request for the new students to generate
these Buddy reports for me during this second 'camp' week. There was a 'leak' somewhere! This may have influenced group behaviour although I could not detect any obvious changes in this regard. One lesson for me from the first 'camp' week was that half a class, sitting at the back of the room, made for a lot of empty space in the room so this time I located all of the groups at the front of the classroom. Once our routine again became routine, with the return of all the students to their usual groups, our environment resumed its collaborative nature.

Students utilise equipment and the space within their room to move around and take measurements. This is a very social but effective activity that produces good outcomes for each set task. One interesting observation from this category arises from a change in classroom venue. The students do not locate themselves in their group sets. As the activity of watching a video does not require this, I suppose this is not surprising. It is most likely that the students simply sat, in what is a cramped seminar room, in the most convenient seat. This month also gave rise to a new phenomenon which, although previously observed, has not been easy to identify or categorise. This relates to the observation, at the end of week 8 for this category, about loud and multi-voiced 'class noise' types of discussions. This works in a most surprising way. The situation is similar to that in which two people, engaged in conversation, are both simultaneously talking and listening. Most people can effectively communicate in this fashion. In our class we have groups of three or four individuals who all simultaneously engage in listening and talking. This multi-voiced discussion is very effective and can examine and resolve matters of interest or concern to the group quite rapidly. Watching students at play in their break times reveals to me that such practice, multi-voiced discussion, is quite a common social skill among their cohort.

It is indeed an indictment of the success of this implementation that these social skills have made a successful transition into our collaborative peer interactive classroom learning environment. We will see more of this.
Observations:
The first section of the observations from this category were made during the second 'camp' week and focused on the temporary groups operating at that time. The first interesting outcome is that Hillary, who spent both weeks at school, did not participate to any great degree during the second 'camp' week. Even though I promote her to the other groups as being potentially useful they do not approach her and she prefers to work alone on a set of extension material I have given her. One of the 'new' groups (Camp Group 2) only has two members for the first few days. These students are from different pre-camp groups and simply do not work well together initially. Even the return from illness of another student into this group does little to improve the situation.
As indicated earlier, I believed these temporary groups were less effective than those that operated during the week 7.

The remaining observations from this category gave specific instances of group activity. Camp Group 5 turned out to be quite an effective group collaborating on and discussing most tasks. Camp Group 2 struggled initially, as discussed above, however by the end of the week they had begun to work much better together. Camp Group 1 worked very well together and even annoyed the other groups, when they met some challenges in the work, by calling out the answers. Camp Group 5 halted this with an effective retort. In my earlier reflections on the constitution and potential work habits of these temporary groups I speculated incorrectly about the controlling influence that the Group 6 student would have on the Group 1 students. Instead, they turned her into an equally boisterous individual. The Group 3 student simply withdrew when placed with the Group 2 students and they did not develop an effective work ethic until quite late in the week. The Group 4 student, who joined the Group 5 students, certainly did gain a lot from the experience, obtaining a great deal of help with the work. I see that only one of my predictions bore any relationship to what eventuated.

The next set of observations from this category was divided into two parts. The first was a collection of specific instances or snap-shots of group activity. Week 9 saw the groups return to their regular structure after the camps and, as outlined earlier, there was an explosion in collaborative activity at this time. The observations for this category reflected this activity.
Of particular note is the observation from this category about Group 2 and Denise which highlights the residual problems with this group.
They are, at this stage, the least cooperative of all the groups as the observations show. Also of interest is the observation from this category which notes Hillary explaining things to her Group 3 partners. This is significant given Hillary’s withdrawal the previous week and given that she did not go to camp and thus missed out on the bonding with the other students that camp could have provided for her.

It was pleasing to see that our collaborative environment was operating well enough to overcome any such possible social problems.

The second part of the observations from this category attended to the situation I created to obtain Buddy reports on those students who had been my 'spies' during the two 'camp' weeks. These are reviewed in the specific events section at the end of this monthly report. The moves were outlined in the observations as were some glimpses of these 'altered' groups at work. Groups 1, 2, 3 and 5 were not working too well while Groups 4 and 6 fared better, especially Group 6.

One final observation is presented below.

9S - The teacher gave a pep talk on the importance of working collaboratively in groups.

This indicated that I felt the need, after the 'camp' weeks, to remind the students about how we did things. Given the resurgence of our collaborative work which followed, this seemed to have been a good idea. Even after nine weeks, I am still, occasionally, reminding the students about collaborative learning environment processes.

**Student support and criticism of each other and the teacher.**

Support has arisen in the form of cross-curricula similarity when the students link work in mathematics to work in their religious education class. There are still instances of poor support among the groups during this second 'camp' week. I am continuing to re-direct requests for assistance to the group and I am monitoring this to ensure that the support needed is forthcoming. If problems remain I help the group work things out. The observations from this category highlight some excellent instances of collective support. In one case the students utilise their "classwide zone of proximal development" (Hedegaard, 1990) to develop their understanding by building on what they knew and then helping each other extend this, using inputs from several students, until they developed the required
knowledge. This represents a very powerful session of student activity in which they develop their new taken-as-shared knowledge by building on their prior experiences.

This was a clear case of "knowledge being constructed, individually and collectively, rather than transmitted" (Burton, 1992, p. 4-5). After this, I had simply to acknowledge the students' success and summarise the outcome, which I did to ensure that all of the students were comfortable with the development of and reasoning behind their new found knowledge. This process was noted in the following observations.

8S - The teacher briefly confirmed the students' ideas and the correctness of their results which encouraged them to go on with the activity.
8S - The teacher talked through the student solutions to clarify the understanding of each step.

In this situation I had reduced my levels of guidance to let the students operate independently. An additional observation, noted below, illustrates the value of having students control the development of concepts, for their peers react well to such situations.

9C - The students' reasons for doing a question their own way led to much reinforcing and supporting of each others ideas.

The students were assuming "more responsibility for their learning by being accountable to themselves and each other" (Behounck et al., 1988, p. 12). The final observation in this section highlights my support for the students' levels of support. I even put my belief to the test as this next observation shows.

10S - The teacher focused on four students (Kerry, Mary, Penny and Amanda) who had earlier indicated that they had trouble understanding this work. Almost all were now clear and a couple asked clarifying questions.

The class was certainly working well in this regard.

Questioning.

In the second 'camp' week I taught the students the same material I had taught the first 'camp' week students. The observations from this category show that I altered my approach to avoid potential learning difficulties and hence I stifled discussion and gave more direction when instructing. This process limited collaboration and the
students did not score as well in their assessments. Not good collaborative practice. This situation may indicate a potential problem or concern for teachers who always teach the same subject or course at the same level. In such cases stagnation, of the teacher, the students and the learning environment, is a very real possibility. The observation from this category on 'answer time' shows that effective but relatively passive collaborative practices were functioning during the second 'camp' week. One observation from this category illustrates my role as a peer in assisting a student to progress into and through her 'zone of proximal development' as Vygotsky described - "what the child is able to do in collaboration today she will be able to do independently tomorrow" (Vygotsky, 1987, p. 211).

Task requirements should be examined and explained with the groups but, as the observations from this category show, I am still doing a lot of this. As the teacher I am usually more effective when making summaries of the main points although the students also need to learn to do this. Thus the role is to share and at times I model the process so that, on other occasions, the students can take on the duty of summarising our work.

One observation from this category highlights a common 'teacher trick' – namely, the use of 'the voice' to inform many while answering one.

**Teacher comments and observations.**

The first observation from this category indicates how students can accept instruction without understanding. Learning is certainly more demanding than listening. The observations from this category again note how I altered my teaching for the second 'camp' week and they also point out how a physical example failed to enhance understanding. Such endeavours are not always successful. Discussion, the role of oral work, is highlighted in the observations from this category and in the following additional observations.

**8S - The teacher used student answers to review an activity set. Each student provided a response. The others corrected when required.**

**8S - The students offer alternatives to the teacher's solutions which are readily accepted.**

Discussing our work “usually leads to seeing things more clearly and often to spotting inconsistencies in one's own thoughts - a process which provides a wonderful opportunity for learning” (von Glasersfeld, 1993, p. 31). However, despite my best efforts, not all incorrect answers could be saved or moulded into correct answers, and not all methods worked! The following observation, and some
of those from this section, show ways in which our process of pooling our knowledge and information led to rapid consensus construction.

9S - The teacher conducted an answer session with all students and all groups being given the opportunity to provide answers.

The observations from this category also show that, at times, there was still too much teacher talk. The habit of "leading rather than guiding" (Voigt, 1985) is still evident. Teaching four other non-collaborative, peer interactive learning environment classes may sometimes cloud my approach in this class. A very interesting observation from this section describes how I recall a student's idea from a previous activity to reinforce a point in our present activity. This shows the class that their valuable contributions are not only useful at the time they make them but also in times of reflection or even in subsequent situations.

"The teacher facilitates the students' mathematical development by subtly highlighting selected aspects of their mathematical contributions" (Yackel et al., 1990, p. 35). The observations from this category also show my continuing role of "assisting individuals and groups" as I "move around the room" (EDWA, 1984, p. 40). This was a valuable feature of our collaborative peer interactive classroom learning environment.

Another observation from this category highlights how the students demonstrate solutions to one another. I model this behaviour to one student in a group who repeats the process for the other group members.

This was a clear example of how knowledge spreads through a classwide 'zone of proximal development', the model for which, I presented in Chapter 2. The observations from this category also show the value to the learning environment of using student answers for a variety of purposes. That the students and I had a good rapport is evidenced from observations in week 9 and in week 10, and the valuing of the subject by one student, seeking a tutor, is also noted. The observations from this category, describing how I gave praise for a contribution and criticism for failing to contribute, are an example of goal setting for the students and the class. Everyone has something valuable to say and all should want to contribute.

The "reward of praise" (Chance, 1993, p. 789) in this situation "serves to 'give permission' to the students to contribute" (Graves, 1991, p. 78) to the class discussion.
Tape recorder and video recorder.
The observations from this category relate to three new phases in the implementation's ethnography: the use of video, to provide a highly detailed perspective of a single lesson; the use of an observer, to probe more deeply into certain aspects of the implementation; and the taking of photographs. Reports on these new phases are presented in the next section along with other specific events for Month 3 including group work in other classes, more Buddy reports, results from the End of Term 1 test and results of the first CLES.

Disconfirming Evidence
During Month 3 a few instances of disconfirming evidence were recorded and noted in the observations, vignettes and associated narratives. This evidence is further highlighted below, in summary form, to exemplify possible limitations in the implementation. Limitations are discussed in Chapter 5.
- extrinsic motivators generated competitiveness and were discarded
- students who remained in the second 'camp' week worked less effectively in their temporary groups
- a renewed teacher-centred focus is evident in the second 'camp' week
- 6D – the students were consulting with the teacher when troubled
- not all second 'camp' week groups functioned effectively in the beginning
- poor levels of support evident in second 'camp' week groups
- Hillary sat isolated during the second 'camp' week
- lessons in the second 'camp' week were altered to avoid known difficulties which consequently stifled collaboration
- excessive teacher exposition – non-collaborative and non-constructivist practices
- poor helping skills and poor explaining skills
- prior knowledge does not always translate into the ability to use this knowledge
- Week 9 – students operating in their own personal worlds – not offering help to anyone else
- was group behaviour influenced by the presence of a 'Buddy' report spy?
- Group 2 and Denise remain a problem
- after the 'camp' weeks it was necessary to remind the students about how we did things
- 9S – the teacher gave a pep talk on the importance of working collaboratively in groups
- the teacher is still explaining most of the task requirements
- students can accept instruction without understanding
Group work in other classes - week 8. (see also Month 2)

During the second 'camp' week (week 8) I surveyed the students present as to which of their other classes / subjects utilised some form of collaborative group work. This information would aid me in understanding more about the learning environments the students' experienced outside our classroom. Other environments do have an impact on what we are doing for "no matter how good a job a teacher does at creating a cooperative community within his or her own classroom, much of this work can be undone when students move to classes with competitive or alienating environments" (Graves, 1992, p. 63). The students' responses are presented in Appendix 4.2.

As was the case with the other half of the class, surveyed the previous week and reported in the specific events section at the end of Month 2, these responses depended on each student's understanding of the terms collaborate and group work. The impression I gained previously was reinforced by these results. I was not previously aware of the extent, in my school, of the use of group work. Camp Group 1 saw group work in all of their subjects but the other students' responses reflected similar outcomes to those from the previous week. One subject group to feature in this survey, but not the previous one, was languages where group work is used for oral, aural language and vocabulary development. English and Science consolidated their group work use with further support in this survey. This data offered further support for the work we were doing in developing our collaborative peer interactive classroom learning environment.

Buddy Reports - week 8: group / week 10: individual (solo)

The next specific event to report on for Month 3 is the group and solo Buddy reports. The students who were placed into other groups for the second 'camp' week (week 8) were asked to write a report for me on the collaborative practices of the group they joined. Their reports are presented in Appendix 4.3. Following on (in Appendix 4.4) are the reports by the students who were asked, in week 10, to review the collaborative practices of each of the students who, in weeks 7 and 8, wrote the original reports. I did this because it gave a complete set of perspectives on the collaborative activity of every student in the class. It was clear, during week 8, that the class was aware of this process and certainly in week 10 the procedure was completely overt. There are no secrets in our collaborative peer interactive classroom learning environment.
These reports, like the earlier ones, were very comprehensive making this exercise a worthwhile one. I do not intend to interpret these reports, for they present a student-based perspective on the groups and on our collaborative peer interactive classroom learning environment. An observation that I shall make is that these temporary groups, made up of half the class to operate during the second 'camp' week, were functioning as collaborative groups although some (Camp Group 1) more successfully than others (Camp Group 5). Our approach to developing a learning teaching environment still strongly influenced this temporary arrangement. Of the solo Buddy reports only the first, by Betty, commented on the group as well as the individual who was the focus of the report.

The majority of the solo reports highlight the often non-collaborative appearance of an individual working in a group. Groups are made up of individuals and thus behaviours, such as those reported in some of the solo Buddy reports, are to be expected.

The other solo Buddy reports described very positive events within the groups. The series of Buddy reports, now complete, gave a vivid view of the functioning of these temporary groups.

While our long term groups are made of different sets of individuals in our class, this data still informs us all as to the strengths and weaknesses of our collaborative peer interactive classroom learning environment at this stage of the implementation. My next step is to ensure that our functional classroom and group collaborative processes continue to be strengthened, and that we also take greater care to nurture the collaborative skills and abilities of each of the individuals who make up our groups and our class.

The Buddy reports played one further, interesting role. At a parent's night, when the parents of the students and I discussed the progress of their daughter, I handed each parent a copy of the information gathered about their daughter from the Buddy reports. This facilitated significant discussion with the parents, many of whom commented on how insightful the observations were.

Photographs - week 9

During week 9 a photographer visited our class to record the groups and their members in action. I informed the students that I wished to have a photographic record of who was in each group. These photographs are spread throughout Chapter 4.
Video report - week 9

As a part of the regular reflections on the ethnographic methodology for this study it was decided to video record some lessons in order to provide a highly detailed glimpse of the groups at work, "a zoom lens effect" (Stenhouse, 1975, p. 153). The video recordings provided rich raw data that I could use to supplement my fieldnotes and daily observations. My review of each video was further enriched through discussion with my research colleague, who made and reviewed the recordings, thereby providing me with "samples of the student's activities, recorded as completely as possible over a limited, but systematic, period of time" (Vasta, 1978, p. 166-167). The students' behaviours (reactivity) was reasonably normal this first time. Reactivity is how "the behaviour of the subjects sometimes changes when they know they are being observed" (Vasta, 1978, p. 178) however later use reduced the students' reactivity for "the reactive effects of observations decrease after a period of time" (Vasta, 1978, p. 178). A full transcript of my observations from the video is presented in Appendix 4.5.

The video transcript is, of itself, a significant narrative. Observations particularly worth re-iterating include:

- friendships extend across groups and are not limited by group design
• tests elicit anxiety
• the way I re-focused student thought on an apparent solution to get a correction, using the phrase 'Why am I upset?'
• the way I get the students to give a more detailed explanation - a nod, then pause and some verbal prompts
• the use of personal situations to bond the class - 'one foot'
• my animation when explaining - maintaining student attention
• my use of student input from a previous lesson to develop the ideas being discussed - 'something Jenny had said'
• the typically quiet start to an activity as students determine what to do
• the way students, who have not finished, work on with one task while the next is being explained - Group 4
• students working with me as a new activity is explained
• my animation as I explain the activity
• the giving of instructions orally
• how certain students - Betty and Jenny (Group 1) - dominate the student input. These students play a significant role in this lesson "in shaping classroom events" (Cooney and Hirsch, 1990).
• students still working on a previous task after a new task is set
• Group 4 is 'aware' of the video camera - other groups are oblivious to the camera
• more discussion as the students engage in the activities
• I am moving around the room completing administrative matters - returning homework
• students working together in their groups and working individually
• my helping various groups and students - Louise then Mary then both
• my not seeing Isobel's request, hand up, for help
• the research colleague (a University mathematics professor) giving Isobel the assistance she needed.

Everyone becomes engaged in our collaborative peer interactive classroom learning environment!
• the success of Group 4 in helping each other do the problems
• the use of volunteers to write solutions on the board
• the role of, and importance of, the group to Hillary - no longer such a strong individualist
• my prompting of students to check and correct their work and their discussions while doing so
• the students' 'interest' in the up and coming test
• the discussion about accuracy which arises in the context being studied
• the role of the class in correcting or completing solutions and hence reaching a consensus about the solutions
• my use of the word or question 'Why?' to extract more detailed explanations from a student - Isobel
• how a student - teacher discussion does not necessarily engage the whole class
• my role in summarising the discussion
• Group 4's reduced interest in the video camera - 'they do not appear to notice (it) moving around the room'
• my role as an additional group member - not teacher - Group 1
• how a group can return to a task, after being distracted, more easily than an individual because the group has 'multiple consciences' - 'Narissa tries to get the group back on task'
• the mix of individual and group work and discussion when working on the set tasks
• how, after the wrap-up of the lesson, some students are still working on their tasks.

These observations highlight many collaborative, and some non-collaborative, aspects of our peer interactive classroom learning environment. They show the students' behaviours and mine (the teacher's), but most of all I see a successfully functioning collaborative learning environment through this glimpse of our class in action. The students and I have a collaborative work ethic and this is evidenced from the video.

So what do the students think of our performance? Appendix 4.6 presents a transcript, from my daily fieldnotes, of the students' responses when shown the video of their class.

From the transcript of the lesson where the students reviewed the video the following observations seem to stand out.
• laughter - we do enjoy and appreciate what we do
• focus on self (television is a magnet to the ego of 13 year olds)
• students noticing the class noise levels
• students agreeing with my observation, that I talk too much!
• good humour and rapport evidenced during this review
• use by me of this review to re-emphasise a point which arose in the lesson - there is always an opportunity to teach!
• role of prior knowledge in the discussion - students have experience with videos
• a student's ability to recall her question as a group-based question, not an individual one - asking on behalf of the group
• my explanation of why I moved around so much - groups / individuals need help and that is my principal role
• my removing the focus from any source of possible embarrassment
• the students' perception that their behaviour was fairly normal
• the point that Mary made about not having enough time to always explain everything to the others in the group
• the need to assure the students of their privacy as regards who gets to see this video
• that the students seemed pleased to have been able to see the video.

Some very useful observations arose from this transcription, particularly the point that time is seen as problematic for the full and correct functioning of our collaborative peer interactive classroom learning environment. It was also noteworthy that the students regarded their behaviour as normal. This gave greater warrant to the value of the video as a data record for this study.

The video provides both myself and the students with a very detailed snapshot of how we function in our collaborative peer interactive classroom learning environment. It is a happy place in which we collaborate, support each other and engage in detailed discussion and explanation of our work. It is not perfect, but we knew that already from our learning environment surveys, however it is working. This is a place where we can come together to learn and where we know others, who care about us, also come to learn. We have space to grow individually and friends to enrich that growth. We would like more time to do our work, but some things are beyond our control. That which we can control has developed quite well. Our successes outweigh our failings. It may be noisy or appear chaotic at times but our new environment is working well for us.

End of Term 1 test results - week 9

Table 10 overleaf presents the individual and group average results for the End of Term 1 test.
Table 10
End of Term 1 test results
(individual and group average)

<table>
<thead>
<tr>
<th>Group</th>
<th>Name</th>
<th>End of Term 1 test result</th>
<th>Group average</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Betty</td>
<td>91.1</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Jenny</td>
<td>88.9</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Cathy</td>
<td>93.3</td>
<td>91.1</td>
</tr>
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<td>2</td>
<td>Emma</td>
<td>48.9</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Denise</td>
<td>84.4</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Amanda</td>
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<td>64.4</td>
</tr>
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<td>Hillary</td>
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<td>Gwen</td>
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</tr>
<tr>
<td>4</td>
<td>Kerry</td>
<td>60.0</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Yvonne</td>
<td>66.7</td>
<td></td>
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As is the practice within our school this test was completed individually. The results were generally poorer than for the Mid-Term 1 test. The End of Term 1 test scores ranged from 31.1% to 93.3% with a class average of 62.8%, down 7% on the Mid-Term 1 test average. These results reflect the heterogeneous nature of the students in our class and the impact of the first algebra topics in our course. The recent camp may also have impacted on some students' efforts. The test covered the topics on geometric shapes, Integers, the Rule of Order of Operations, functions and relations.
(algebra) and 3D shapes. More than half the test focused on the algebra work alone. Our class average was 13% below the year cohort average, reflecting the fact that ours was one of the normal stream classes and not one of the accelerated stream classes.

As predicted from the previous test, the algebra work has proven quite difficult for some of the students. Groups 1 and 3 both improved on their Mid-Term 1 results but all the other group's results declined. Eight of the twenty-one students in our class improved their results compared to Mid-Term 1 and this included all of the students in Group 1. None of the students in Groups 4 or 5 improved their results. Many of the individual students were disappointed with their performance while others were quite pleased. However, all of the students were pleased with the group averages which showed that all the groups had passed this assessment.

Group 1's result singles them out as the most able group of students, however the other groups were of similar ability to each other. As our course unfolds each test will contain a greater variety of material. We face two further assessments next term, so we will have to continue to work hard to improve our results where possible. I hope these results, on an individual-based activity, do not dampen our enthusiasm for our collaborative peer interactive classroom learning environment.

Observer report - week 10

As a part of the regular review of the ethnographic methodologies associated with this study it was decided to ask a research colleague to sit in on some lessons to observe the class activity and ask questions of the students about particular facets of our collaborative peer interactive classroom learning environment. This process would provide an alternative perspective to mine and would probe certain issues to greater depth. "A teacher who wishes to take a research and development stance to his own teaching may profit at certain stages in the development of his research by the presence of an observer in his classroom" (Stenhouse, 1975, p. 155). The resulting data would help me monitor circumstances within the study and thereby enhance the rigour of the evidence emerging from the data. A full transcript of the observer's report is presented in Appendix 4.7.

The observer's report is, of itself, a significant narrative of our class at work. Observations worthy of highlighting include:

- students self starting on arrival to class
• extra time given to complete homework, including some in-class time to clarify what needs to be done
• groups were busy and on task during their discussion time
• students asked questions of the teacher
• to the observer, the students appeared to be trying to improve their understanding
• my practice of letting the group help the student was apparent
• the students' knowledge base appeared to be growing as a result of discussion in the class
• discussion involved many interactive processes
• not contributing did not mean not participating
• groups were engaged in a variety of collaborative activities when next working on some tasks.

These observations are very supportive of the aims for this study. My aim was to develop a functional and effective collaborative peer interactive classroom learning environment. These observations illustrate how successfully we had been in achieving this aim. A collaborative environment where instruction leads development, peers assist each other to learn, individuals blossom and groups flourish. Where past knowledge merges with new concepts and consensus is negotiated through discussion of problems and solutions. An environment where everyone can collaborate at whatever level to produce a better outcome for all involved. These observations encourage us, myself and the students, to continue with our implementation.

**Constructivist Learning Environment Survey (CLES #1) - week 10**

The final specific event to report on for Month 3 is the first use of the Constructivist Learning Environment Survey or CLES. From the data collected through the CLES, shown in Table 11 overleaf, class and group charts were produced and these are shown, on the following pages, as Figures 14 and 15. These were analysed to determine future actions aimed at further enhancing our collaborative peer interactive classroom learning environment along the lines we desired and within our theoretical and practical guidelines.

The charts were presented to the students and the outcomes were discussed in class. A transcription of this discussion is presented in Appendix 4.8.
<table>
<thead>
<tr>
<th>Name</th>
<th>Group</th>
<th>CLES type</th>
<th>N</th>
<th>PK</th>
<th>A</th>
<th>SC</th>
</tr>
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<tbody>
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**Group 1**

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Figure 14
CLES 1 Class Graph
Figure 15
CLES 1 Group graphs
Three of the CLES attributes of a constructivist environment scored very well, Negotiation, Prior Knowledge and Autonomy. The Student-Centredness scale achieved only an average score. This implementation was not focused solely on the constructivist paradigm, rather constructivism guided and helped mould the theoretical foundations for the implementation. Therefore I am very pleased with this first measure of our performance from a constructivist perspective.

One could be quite concerned about the Student-Centredness attribute, assuming this was a measure of collaborative group work, but this was not the case and besides, the more significant interpretation relates to the difference achieved between what the students perceive and what they would prefer on each of the attributes. On this measure, the difference for Student-Centredness was the least for all the attributes, indicating that our environment was meeting the students' needs in this regard. The gap here was most likely the result of the occasional excesses of the teacher in terms of giving lengthy instructions. This habit was noticed in earlier observations and had been decreasing. Of course the work, the mathematics, by its nature, was not student-centred for it presented as a power or authority that challenged the students to master it. They knew that, with their group's help, they could master it, however the 'persona' of the subject was not perceived as student-centred or student friendly.

We fared next best in the attribute of Autonomy. Our difference measure here was also quite small, and thus the students were fairly content with their level of control within their environment. Of course many things were beyond our control, such as what group we were in, what topics were in the course, how long we got to do each topic and the need to work our tests individually. However, for those aspects of our environment over which we had some control we were satisfied with the degree of freedom we had. We were similarly satisfied with the Negotiation attribute which also had a small difference measure from perceived to preferred. As our environment had emerged the students' role in developing the concepts had increased and this result showed that we could still improve in this regard although we were very near to matching our preferred level. Although this attribute had a very high score we could still aim to improve it. Finally there was the Prior Knowledge attribute. On this attribute we had the largest difference between the level we preferred and the level we perceived we were at. Despite what I suggested in the transcript, I believed that it was the frustration of not having very much prior knowledge, particularly in the functions or algebra work, which had led to this gap. The perceived score for Prior Knowledge was in fact quite high but the students would have preferred an even higher outcome which further supported my
interpretation. If we were ignoring their Prior Knowledge then the perceived score
would not be so high. A further factor which I saw influencing this scale was its
measure of the differences in Prior Knowledge between the students. Those with
weak backgrounds would push up the preferred score and hence this also contributed
to the difference measure of this attribute.

Overall, as a first score card on the level of constructivism evident in
our collaborative peer interactive classroom learning environment, we
have a very pleasing set of outcomes.

As indicated in the transcript, each group had a fairly good set of outcomes for each
attribute. Group 3 had a very good match which, with the exception of the Prior
Knowledge attribute, was reflected in the results for Group 5 (next best match) then
Group 2, Group 6, Group 4 and Group 1. The fact that Group 1's result had the
lowest match rate may have motivated Jenny's statement which was noted in the
transcript. My comment about lacking in Prior Knowledge seemed pertinent to
Group 2 and Group 4 and matched the sentiment of my comments to them noted in
the transcript.

As to the influence of this data, I feel I must answer each request for
improvement even if an attribute scored highly, as three of them did.
The priority is with Prior Knowledge. I can value that which the
students offer, more highly, and avoid any references to their lack of
Prior Knowledge in other areas. This is a bit like ignoring a deficiency
but our quest is to learn new things, not lament a lack of earlier
learning which we can pick up on as we go forward. This positive
approach seems the best path to take. We can improve the Student-
Centredness outcome if we continue to keep teacher talk to a
minimum. We can improve the Autonomy outcome by having the
students guide more of the activities, such as selecting questions to
do from a large set, or to do for homework, and these changes should
also positively influence the Negotiation attribute. These will be our
aims over the next term.
Term One Review

This review represents a very broad synthesis of observational trends gleaned from the data collected and reported on in the first three months. A focus within this review is given to the research methodology of the study, to ensure the adequacy of the data collection and data synthesis procedures currently in use.

I have tried to maintain a collaborative environment within which the students learn. At times this is not the case, but awareness of this focus will ensure it remains our primary goal. I have used several techniques to highlight the value of collaborative work and these will have to be ongoing, with further discussion of the ideas on how to make it work.

The course content, being so rigidly set from one text source, does allow for collaborative work in most topics (not all), but is not always sympathetic to the varying backgrounds of the students nor to their capabilities. These difficulties are challenges for the groups to take on and this point needs to be emphasised. I am, at all times, attempting to develop positive attitudes to mathematics in the students and should continue to do so.

Several incidents have arisen where the relationship between mathematics and society has surfaced and where the students describe their mathematics in the context of prior experience. I have attempted to value these points when they have arisen. I have attempted to value and respect the students’ input and to this end often request students’ opinions and solutions to problems. I have often highlighted the value of students’ work in an attempt to enhance their self esteem.

Discussion is the primary form of information development in the class and must remain so. The discussion is actively engaging the students in their groups. Several incidents have revealed that the students have developed a willingness to express their thoughts openly, with confidence and without fear of contradiction, except from other students of course. The students have developed their abilities to negotiate and compare their knowledge through communication within their groups and within the class quite significantly. They have also developed the ability to critically evaluate and reflect on each other’s work.

Several observations and references have been made in the fieldnotes to the students working in their proximal ‘zones’ and these comments are designed to highlight those
events, and to reinforce to the teacher researcher, the Vygotskian perspective of the study. Several incidents of extension into the proximal 'zone' have been observed and noted.

The teacher-as-researcher has been, and shall continue to be critical of his own practice. Occasionally my exposition has exceeded preferred levels and this will have to be closely monitored in the future. Variety in lesson delivery is required however, and this means that not all lessons will be, or need to be, of a collaborative nature. The roles of teacher and student within the class room have frequently been reversed and the teacher often illustrates that he is not the 'expert'. This process needs to be nurtured and encouraged. The value of collaboration has been reinforced through the incorporation of group marks into the students' assessment profiles and this practice must be continued and highlighted to the students.

While the groups were originally formed on the basis of a wide selection of information about the students it has become clear that they are not well balanced in terms of their mathematical or their general abilities. Group 1 in particular seems quite strong while Group 4 seems fairly weak. This situation will need to be carefully monitored as the groups will remain in their present form for another term. This will further develop the students' collaborative skills.

Triangulation has been enhanced during the term through the introduction of a video taped lesson and the observations of an independent researcher. The class seems quite at ease now with the tape recorder being in the room. Additional support for triangulation purposes exists in the collection of student data in the form of written work, tests and attitudinal / environment questionnaires. The students have compiled a list of the subjects in which they are working in groups and photographs have been taken of all the students in their group sets and of them working in their groups. Secret surveys and Buddy reports have been collected from the students as measures of their perceptions of each other and their collaborative practices and attitudinal measures have to be taken to provide a focus on ways to improve the learning environment. These are a vital source of data.

Disconfirming or alternative evidence was plentiful in the early stages of the study but has seemed to have dwindled off of late. The researcher teacher must ensure that such data is still being recorded. The teacher researcher feels that the data being observed, collected, and reported on is contributing to the development of answers to the research questions originally posed by this study.
Term One assessment review

This next section presents a summary of the students' non-test assessment scores for Term 1. During Term 1 each student obtained a score for the following non-test assessments.

Table 12
Term 1 non-test assessment items

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<th>NAME OF ITEM</th>
<th>Value scored out of</th>
<th>Value score converted to</th>
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<td>Mental 2 - group avg</td>
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<td>Homework 2 - grp avg</td>
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<td><strong>TOTAL</strong></td>
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</table>

Items in italics represent bonus score items. Students were awarded additional or bonus scores based on their results in various assessments. Bonus scores were derived by taking the groups average score for an item and then allocating this as the bonus score for each member of the group. Even if a member of the group scored
a zero, everyone would still accrue a bonus score. Thus the better everyone's effort the more bonus score everyone stood to gain. Such a policy parallels the underlying premise of "positive interdependence" and "individual accountability" (Johnson and Johnson, 1990, p. 30) in which students are rewarded for their individual efforts and for the efforts of their group members (including themselves) with collective scores. Getting the best possible score you can is a measure of your individual accountability. Getting the best possible bonus score relies on you getting your best possible score and helping the other members of your group to get the best possible scores they can achieve. This is a measure of positive interdependence. Everybody gets at least their own score so no one loses any score under this scheme. Students can only gain by accumulating bonus marks as an extrinsic reward for their collaborative work.

The final non-test score for the term was converted to a percentage and entered into the school database as the Term 1 teacher mark. A summary of the final Term 1 percentages for each student is given in Table 13 overleaf.

A complete analysis of results for the semester, the point at which grading occurs, is given at the end of the observations for Term 2. The following observations offer brief comment on these Term 1 results at this stage:

- Betty, Jenny, Cathy, (all of Group 1), Narissa and Stacey are all very able mathematics students who performed very well in the End of Term 1 test.
- Denise, Isobel and Vicky are of 'average' ability and have also performed very well in the End of Term 1 test.
- Amanda, Faye, Kerry, Yvonne, Penny and Wendy are of 'average' ability and this is reflected in their good ('average') End of Term 1 test performances.
- Hillary is of similar ability to Amanda and company however, her ability has improved significantly as the term progressed resulting in her achievement of a very good End of Term 1 test result.
- Emma, Gwen, Louise and Trudy are all of 'average' ability but have struggled with the End of Term 1 test obtaining quite poor scores. Louise's and Trudy's results are particularly disappointing and may reflect the impact of Algebra on their overall performance.
- Mary and Robyn appear to have quite low levels of ability in mathematics. They might be described as 'weak' students. Robyn's high teacher mark reflects the level of support she receives from her peers in Group 5.
<table>
<thead>
<tr>
<th>Name</th>
<th>Group</th>
<th>Teacher Mark %</th>
<th>Mid-Term 1 test %</th>
<th>End of Term 1 test %</th>
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<tr>
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<td>Louise</td>
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<td>Robyn</td>
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<td>Penny</td>
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<td>Trudy</td>
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<td>Vicky</td>
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</table>
SECOND TERM

April / May  -  Weeks 11 to 13 (inc)
May / June  -  Weeks 14 to 17 (inc)
June / July  -  Weeks 18 to 21 (inc)

This next section presents highlights from the narrative for the observational data collected during weeks 11 to 21 of the implementation, Term 2. The observational data referred to is presented in Appendix 5. The narrative is delineated into the categories described in Table 1, and is similar in structure to Month 1. The category Group Work ethic / process is further divided into additional criteria as discussed earlier. Following the highlights from the narrative for the observational data, highlights from the narrative for the data arising from specific events is presented. For Term 2 these include a report on the second video review of a lesson, a report on the observation of the class by a research colleague, the results of the Mid-Term 2 test, the results of the End of Term 2 test, the results of the group-worked End of Term 2 test, another report on the observation of the class by a research colleague, a report on a further video review of a lesson, the results of a special group-worked test and yet another report on the observation of the class by a research colleague. Each reflective narrative examines and highlights key points from the observed data and discusses the progress of the implementation from the context of that category.
A reminder that raw observational data is presented in Helvetica font, vignettes are presented in Bookman font, and the thesis commentary or report remains in normal Times font.

Month 4  -  Weeks 11 to 13 (inc)

Observations for Month 4 are presented in Appendix 5.1.

Group Work ethic / process.
(a)  Discussion / Explanation
The observations from this category outline the excellent standard of multi-faceted discourse which occurred within our collaborative peer interactive classroom learning environment. Our discussions allowed students to "get information they did not have", "receive feedback from their peers", "identify gaps in their understanding", "explain something to someone" and "have something explained for them" (AEC, 1990, p. 19; Vacc 1993, p. 225).
Our discussions can be very engaging as the observations from this category note.
Our 'all in' affair provided clear evidence of "the social nature of learning" (Newman and Holzman, 1993, p. 70). The observations from this category also note how we had a lively debate which, in the end, could not be resolved. Now that sent the students home with something to think about! This would rarely occur in a non-collaborative environment for there, the teacher would have just told the students the answers. I was glad we were not like that.

(b) Background
One observation from this category, that some groups are advantaged due to their expertise, is a significant one. Advantaged groups have a wider collective 'zone of proximal development' and this allows them to proceed with a new task. Groups with a narrower 'zone of proximal development' need to have a more capable peer or teacher join with them and extend their collective 'zone of proximal development' so they can acquire the knowledge and understanding they need to complete the task.

In our collaborative peer interactive classroom learning environment "each child acquired personal knowledge through the activities shared between the teacher and the students" (Hedegaard, 1990, p. 361). Our environment continued to help everyone gain knowledge, learn new concepts and understand more each lesson.

(c) Behaviour
From the observations for this category we can see how our collaborative peer interactive classroom learning environment is functioning very successfully, so successfully in fact that the students often take over the activities or determine their own direction. I am reduced to simply another learner amidst a collective of collaborative learners.

(d) Help
Evident in this category are more observations showing how well the environment worked during these weeks.

Students willingly taking on the role of teacher (a less able student showing through in this case!), improving on my explanation and correcting me. Do I want all this help? Yes, it is nice to have a class of learners teaching - or are they teachers learning?
(e) Month review - Group Work ethic / process
The additional observations from this category were made while reviewing the
Group Work ethic / process for this month. They further enrich my warrant for
claiming that our collaborative peer interactive classroom learning environment was
functioning successfully.
My synthesis of all of the observations dealing with the Group Work ethic / process
for Month 4 led me to the following conclusions:
  • our collaborative peer interactive classroom learning environment was working
    very well this month - great discourse, even lively debate - good behaviours -
    strong moves towards independent action by the students - students taking on the
    teacher's roles
  • many opportunities arose for us to work within and develop group or collective
    'zones of proximal development' and our classwide 'zone of proximal
    development'
  • many instances of peer teaching

The environment - group size and effect / layout.
The sole observation from this category reflected on our work environment this
month: the students worked well with equipment. However there was also mention,
(for the first time!), of students' interest in re-grouping. In answer to the Johnsons'
question, reported in Chapter 2, of trying "different lengths of time or searching for
crucial signals that groups should be changed" (1991, p. 48), it may be that after
eleven weeks the time to think of changing groups had arrived. We still had ten
weeks to go to the end of term!

Student support and criticism of each other and the teacher.
The observations from this category showed the very strong network of support
which continued to be evident during Month 4. A benefit of such an environment
was that the students felt free to try their ideas, take risks and maybe make mistakes.
For students to become effective learners of mathematics, they must
be actively engaged, want and be able to take on the challenge, persist
in effort and take risks. For this to occur the student must personally
experience a supportive environment, with mathematical challenges,
which promotes and enhances sustained and robust learning (CC,
The observations from this category also show how the individual is
important in our collective as we empower minority views and allow
students to disagree with our taken-as-shared consensus.
Classes such as ours "must be willing to entertain suggestions from students and suspend judgment about their ideas" (NCTM, 1989, p. 245) thereby "remaining open to creative student solutions" (Lochhead, 1992, p. 551).

**Questioning - group focus.**
The observation for this category contains a powerful example of collective learning. Events like these are the reason why we all put so much effort into developing our collaborative peer interactive classroom learning environment.

In the next section, we will examine two of the specific events from Month 4, namely a report on another video recording of one of our lessons, and a report on another visit to our class by a research colleague.

**Video report - week 12**

The video recording provides rich raw data that I use to supplement my fieldnotes and daily observations. My review of each video was further enhanced through discussion with my research colleague who made and reviewed this recording. A full transcript of my observations from this video is presented in Appendix 5.2.

The video transcript is, of itself, a significant narrative. Observations particularly worth re-iterating include:

- the social nature of our collaborative learning environment
- lessons proceeding with checks on students' work to gauge the pace for instruction
- our normal work practice of attempting problems, getting help, discussing solutions
- students' participation through listening (Peterson and Swing, 1985)
- my calling on students for further explanations and contributions
- correction by the students of my work
- correction of a student's work by the other students
- my feigning ignorance to solicit student resolution of a student question
- use of a student misconception to both explain the process to her and reinforce the method to the whole class
- my level of animation when instructing
- use of students' input to build up the knowledge base for discussion - this is a case of my teaching "the students how to use their preconceptions in the learning process" (Ali, 1991, p. 81)
• good rapport during discussion which is free flowing and engages many of the students in an active role
• student explanations of solutions or methods in answer to a fellow student's question
• the use of analogy and a practical experience within the prior knowledge experiences of each student to define and explain a new concept
• excitement and emotion from me (I am happy!) when the students get the work correct
• students sharing these emotions in their work (although they also get quite critical of themselves if they go wrong - a bit harsh I thought)
• my withdrawal from an activity and the students' responsible response in their continuation with the task
• more praise and compliments from me for good work
• automatic peer teaching when explanations were given to aid progress
• my ceasing an activity on a good result - to 'capture the success'
• students helping each other on the tasks
• my help for Penny, which then becomes the subject of group discussion as the ideas and comments are shared.

This last point is a good example of the dynamics of my model of a classwide 'zone of proximal development'. Teacher assists student, student assists other students and so on across the 'zone'.

The observations from the video recording highlight many collaborative, and some non-collaborative, aspects of our classroom learning environment. They illuminate the behaviours of the students and myself and give a view of our highly interactive environment as we 'watch' our class in action. Our functioning collaborative work ethic is clearly presented and the observations from the video recording add to our warrant regarding our belief in the success of this implementation.

Observer report - week 13

This next section is a report on another visit to our class by a research colleague who came to observe us working and ask questions about particular facets of our collaborative peer interactive classroom learning environment. This report provides us with an alternative perspective and allows issues to be probed to greater depth. The resulting data enhances the rigour of the evidence emerging from this study. A full transcript of the observer's report is presented in Appendix 5.3.
N.B. - Comment regarding the previous Observation session:

[Positive comments by the observer last time regarding this classes ability at metrics, made during our first lesson on it, were confirmed as being partially due to the fact that the students had studied this work in another subject, science.]

The observer's report, of itself, is a significant narrative of our class at work. Observations from the observer's report worthy of highlighting include:

• student correction of answers
• my giving explanations and examples to set the task
• Narissa's leadership and peer help role in her group
• blackboard-based review of problems which caused concern
• students are working in groups and do need help (from the variety of sources) from time to time
• most of the students are willing to try the work - they have a positive self image
• good discussion in groups
• students seek reassurance on their methods to avoid going off on the wrong track.

Comment:

[Pick a consolidation lesson and it will be easier to wander around.
The Observer didn't feel able to interrupt a lesson, to ask students specific questions, when they were all working on trying to understand new concepts.]

It was the intention of the observer to get among the students to probe issues more deeply this session, however she felt that such disruption to the students when they were working so hard would have been inappropriate. Learning and teaching must always win out over research. She can try again next time. The observations from the observer's report reflect well on the development of our collaborative peer interactive classroom learning environment and illustrate many positive facets of its operation. They also provide a valuable snapshot of how we went about our business in our lessons.
Month 5 - Weeks 14 to 17 (inc)
Observations for Month 5 are presented in Appendix 5.4.

Group Work ethic / process.
The observations from this category continued to illustrate how successfully our collaborative peer interactive classroom learning environment was operating. The groups were observed to be functioning well in each of the four weeks. In one special observation, shown below, we saw again that this success depended in part on the evolution of our discussions into something more akin to conversations.

15C - The students are in a very collaborative, open discussion type mode as they work today. Discussion is not like teacher exposition at all, much more like conversation.

One observation from this category illustrated how the students gave better help to other students than, in that case, I could provide, once again showing how easily our environment enabled the "roles of teacher and student to be reversed" (Forman and Cazden, 1985, p. 329).

Figure 16
Group 4: Yvonne, Kerry, Mary and Louise
(a) Discussion / Explanation
The observations from this category again address, as they did last month, the degree to which discussions resembled conversations - a mark of quality discourse. The students were discussing, I was explaining, the entire scene was very interactive, providing "appropriate mathematical challenge through engagement in mathematical discussion and debate with peers" (CC, 1997, p. 202). The class is full of good, engaging, informative discussion with many forms of discussion in evidence. There are individual discussions, class discussions, group discussions, simultaneous discussions and then, there are conversations!

(b) Background
When our new work built on some of our old work I found it was important to highlight the students' prior experiences for this allowed us to "reflect on our practice" (EDWA, 1984, p. 7-9). Working collaboratively allowed the students to "reflect upon what they have found from their mathematical work, thinking about what did and did not work and why, and how it connects to other mathematical concepts and processes" (CC, 1997, p. 202) and it allowed me to "identify a zone range to focus instruction on in our classroom" (Tudge, 1992, p. 1365).

The observations from this category show that the students have prior experiences to contribute; that I seek and utilise these; that prior experiences can be recent experiences; that we are all aware of our 'short-fall' in regards to our prior experiences, and that we have in place processes whereby we can acquire the necessary prior knowledge to progress in our learning. Together we can.

(c) Observations:
The observations from this category are snapshot examples of class activity during the four weeks making up Month 5 of our implementation. The more interesting features evident in this data include:
• the success of the groups in answering questions depend in how well they have helped each other
• the groups have mixed approaches to the work
• assessments by me of how well each group, each individual, is coping with the current work
• Group 4 has very low self esteem and lacks the confidence to get on with the work without support from me
• students are responsive during question time
• the students try a variation on our usual grouping arrangements
• once we were outdoors the concept of a group or team fades, initially, and
  individual personalities rise to dominate or withdraw to a distance
• all groups are engaged in some periods of discussion
• there is wide spread interaction for all but a few of the students when working on
  a task.

The observations from this category are very specific, often capturing
only a few minutes of activity, yet they provide a mosaic view of how
we worked this month. The work seems difficult, we need and get a
lot of help, we get tired, we don't always get along, but most of the
time we work well together in our collaborative peer interactive
classroom learning environment.

(d) Month review - Group Work ethic / process
My synthesis of all the observations dealing with the Group Work ethic / process for
Month 5 led me to the following conclusions:
• our collaborative peer interactive classroom learning environment continues to
  function well even under the stress of an increasingly difficult programme of
  mathematics and associated assessments
• our discussions are frequent, dominant in terms of time, variant in that they take
  on many forms and often turn into conversations
• our level of explanation is similarly high
• the level of interaction is also very high
• our work cycle continues in the form it has held since Month 1 - attention to
  instruction, questions for clarity, discussion within groups, individual working
  and more group discussion and checking - this pattern then oscillates through
  quiet working, discussing the methods / solutions and giving or receiving of help
• the quality of the students' collaborative activity is very high
• we have a happy, jovial atmosphere (most of the time)
• tests alter our (individual/group/collective) persona

Overall we seem to still be collaborating well and enjoying good
interactions with our peers as we learn. This is the nature of the
environment in our classroom.
In the next section, we will examine four of the specific events from Month 5, namely the results of the Mid-Term 2 test, a report on the third video review of a lesson, the results of the End of Term 2 test and the results of the group-worked End of Term 2 test.

**Mid-Term 2 test results - week 15**

Table 14 overleaf presents the individual and group average results for the Mid-Term 1 test.

This test was an individual test as is the policy for such assessments at our school. The results ranged from 25.9% to 92.6% with a class average of 59.5%, down 3.2% on our last test. From a class perspective these results show a further decline in our academic performance. The test consisted of mostly algebra work with some measurement work and it was a difficult test. Four of the groups’ average scores fell while two of the groups (Groups 4 and 6) increased their group average scores. Eight individual students improved their scores in this test which was quite an achievement. They were Amanda (Group 2), Gwen (Group 3), Mary, Louise and Yvonne (all Group 4) and Stacey, Trudy and Wendy (all Group 6). The Group 6 students could attribute their success to their group which was working very well at this time. The students in Group 4, our least able group academically, could be very pleased with their performances. A lot of hard work went into their achievement of these results. Groups 1 and 6 were vying for top academic group status, (if we had such a thing!), and despite some lower figures, all of the groups were pleased that they collectively passed the test. It was only two weeks before our End of Term 2 test and we would all have to work hard to ensure our results improved for that assessment.
Table 14
Mid-Term 2 test results
(individual and group average)

<table>
<thead>
<tr>
<th>Group</th>
<th>Name</th>
<th>MID - Term 2 test result %</th>
<th>Group average %</th>
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</thead>
<tbody>
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<td>Betty</td>
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<td>Jenny</td>
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<td>1</td>
<td>Cathy</td>
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<td>Emma</td>
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<td>61.1</td>
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<td>Hillary</td>
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<td>Gwen</td>
<td>50.0</td>
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<td>Faye</td>
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<td>Isobel</td>
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<td>Mary</td>
<td>55.6</td>
<td></td>
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<td>4</td>
<td>Kerry</td>
<td>50.0</td>
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<td>4</td>
<td>Yvonne</td>
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<td>Louise</td>
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<tr>
<td>6</td>
<td>Vicky</td>
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<td>69.4</td>
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</table>

The next test is the final assessment before classes are restructured based on academic achievement over the first semester. Due to the importance of the next two weeks I decided to review this Mid-Term 2 test performance with each of the students. The transcript of these conversations is presented in Appendix 5.5. The comments reflected the endeavours described earlier. Many students needed a confidence boost and this was time well spent.
End of Term 2 test results - week 17

Table 15 overleaf presents the individual and group average results for the End of Term 2 test.

Our school policy was for tests to be sat individually and this is what we did for the End of Term 2 test. After seventeen weeks of collaborative work, this individual test approach was quite frustrating. The End of Term 2 scores ranged from 29.1% to 80% with a class average of 57.1%, down 2% on the Mid-Term 2 test average. Again our results are down slightly from our previous assessment but it does appear that our rate of decline has slowed. This test contained material from all the topics we have covered to date in the semester.

Two of the groups improved their overall results while the average scores of the other four groups fell. The students prepared hard for this test and certainly tried their best. A result of 29.1% may not seem like a good score, but if it was better than last time, then it was an improvement. No one could criticise any of these students - they tried their best - we could not ask for more. Eight of the students improved their individual scores in this test, a feat of which they could be proud. They were Jenny (Group 1), Emma, Denise and Amanda (all of Group 2), Faye (Group 3), Kerry (Group 4) and Narissa and Penny (both from Group 5). Amanda had now improved twice in two tests and is the only student in our class who had done so. The Group 2 students had really worked hard to help each other and their results were pleasing reward for their efforts. Group 1 had re-affirmed their place as our most academically able group and were to be congratulated on their achievement. All groups collectively passed this test continuing an unbroken run in our collective record for the four major assessments this semester. Our class average was only 8% below the cohort year average (13% at the end of last term) so we were improving (or they were declining rapidly in our direction!). As one of the mixed ability groups, we had achieved results which matched our level and many of the individual students were very pleased with their results.
Table 15
End of Term 2 test results
(individual and group average)

<table>
<thead>
<tr>
<th>Group</th>
<th>Name</th>
<th>End of Term 2 test result</th>
<th>Group average</th>
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<td>Cathy</td>
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<td>Denise</td>
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<td>29.1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Isobel</td>
<td>70.9</td>
<td>57.0</td>
</tr>
<tr>
<td>4</td>
<td>Mary</td>
<td>51.8</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Kerry</td>
<td>51.8</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Yvonne</td>
<td>62.7</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Louise</td>
<td>41.8</td>
<td>52.0</td>
</tr>
<tr>
<td>5</td>
<td>Robyn</td>
<td>29.1</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Narissa</td>
<td>80.0</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Penny</td>
<td>61.8</td>
<td>57.0</td>
</tr>
<tr>
<td>6</td>
<td>Stacey</td>
<td>64.5</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Trudy</td>
<td>43.6</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Wendy</td>
<td>52.7</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Vicky</td>
<td>55.5</td>
<td>54.1</td>
</tr>
</tbody>
</table>

Tests are the bane of our collaborative peer interactive classroom learning environment. We work really hard each and every lesson trying to improve our collaborative practices, then, when it comes to earning marks for grades to reflect our work in mathematics, we have to sit tests alone and in isolation. My frustration is a reflection of, and contribution to, the collective frustration our whole class feels on this matter.
Test marks were supplemented with non-test marks for the determination of grades (analysed in a later section of this Chapter). The non-test marks for our class reflected our collaborative practices. Although this thesis only reports the outcomes of one semester's implementation, it was intended to continue developing and utilising our collaborative peer interactive classroom learning environment throughout the remainder of the year, semester 2. Thus with a view to the future, (what could we do about these tests which focus on the individual?), and an awareness of the frustrations of the present, as hinted at by the students and noted in the observations, I hatched a plan.

Unannounced, I produce a new set of the End of Term 2 test a few days after the students sat the original test. The students are in shock. 'But we've done this!' they cry. 'Quiet!', I retort, 'this is a test. Prepare yourselves and your equipment accordingly'. They do so, silently, in a state of disbelief. One of the students (Yvonne) calls out 'we've got an extra copy'. Time to let out the surprise. 'Of course you have a spare copy, this test is to be done in groups!' Gasps of amazement then sighs of relief as they realise this is not a 'serious' test. 'Please work together and only submit one copy from each group for marking. Now begin'. The noise is loud.

Thus it was that we introduced a new concept to our collaborative peer interactive classroom learning environment: collaborative group-worked tests. Research "should not only contribute to the growing base of scientific knowledge about mathematics teaching and learning but also complement and inform the efforts of mathematics educators to reform assessment practices" (Research Advisory Committee of the NCTM, 1988, p. 343). I recommend this idea to anyone who is engaged in collaborative classroom practices. Group-worked tests were a terrific idea. My students loved them and I fully intended making all future assessments, all those not set as common tasks with the cohort year group, group-worked assessments to match the nature of our collaborative peer interactive classroom learning environment. So how did we do?
End of Term 2 GROUP-WORKED test results - week 17

Table 16 overleaf presents the results for the End of Term 2 group-worked test. Each student in any one group, received the same mark as every other student in her group. Therefore the group's group-worked score was also the group's average. This can be compared to the group's average score from the 'official' End of Term 2 test. The group-worked tests were included in the set of individual tests and marked according to the given marking key. We did very well. Group 1 had an outstanding result. Next was Group 3, then Group 6, Groups 2 and 4 and finally Group 5. Narissa, from Group 5, was absent on this group-worked test day. She was the most academically able member of her group and was our class top score in the 'official' End of Term 2 test. Robyn and Penny did their best and scored 53.3%
Table 16
End of Term 2 Group-Worked test results
(compared to End of Term 2 individually-worked group test averages)

<table>
<thead>
<tr>
<th>Group</th>
<th>Name</th>
<th>End of Term 2 Group-Worked test result</th>
<th>End of Term 2 individually worked group test averages</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Betty</td>
<td>99.2</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Jenny</td>
<td>99.2</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Cathy</td>
<td>99.2</td>
<td>63.3</td>
</tr>
<tr>
<td>2</td>
<td>Emma</td>
<td>70.0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Denise</td>
<td>70.0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Amanda</td>
<td>70.0</td>
<td>61.8</td>
</tr>
<tr>
<td>3</td>
<td>Hillary</td>
<td>86.7</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Gwen</td>
<td>86.7</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Faye</td>
<td>86.7</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Isobel</td>
<td>86.7</td>
<td>57.0</td>
</tr>
<tr>
<td>4</td>
<td>Mary</td>
<td>70.0</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Kerry</td>
<td>70.0</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Yvonne</td>
<td>70.0</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Louise</td>
<td>70.0</td>
<td>52.0</td>
</tr>
<tr>
<td>5</td>
<td>Robyn</td>
<td>53.3</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Narissa</td>
<td>absent</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Penny</td>
<td>53.3</td>
<td>57.0</td>
</tr>
<tr>
<td>6</td>
<td>Stacey</td>
<td>80.8</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Trudy</td>
<td>80.8</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Wendy</td>
<td>80.8</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Vicky</td>
<td>80.8</td>
<td>54.1</td>
</tr>
</tbody>
</table>

compared to their joint average of 45.5% in the 'official' End of Term 2 test. Thus we claimed that every group did better in the group-worked test than they did in the individual test. Collaboration works. The collective knowledge of the students was greater than that of the individuals in isolation. With the exception of Penny in Group 5, everyone scored more as a group member than they did as an individual. Outstanding! I wonder what their potential is in a class worked test? - (no teacher help allowed). We might try this next.
For the group-worked test our scores ranged from 53.3% (everyone passed) to 99.2% (made a silly mistake!) with a class average of 78%, our best result so far this year and a clear 21% better than our average in the test completed as individuals. These numbers proved to be very, very powerful motivators for the students. Perhaps there was something to this collaborative stuff after all?! "Will all future tests be group-worked?" Jenny of Group 1 asked. "Ah, regrettably not", I had to reply, dampening the students' spirits, "but all that can be will be," I promise, raising their spirits again.

On that happy note we turned our attention to the tasks and activities at hand and resumed our collaborative endeavours. The atmosphere had changed. Our collaborative peer interactive classroom learning environment held new promise. The next month was going to be interesting as we saw out the semester.
Month 6 - Weeks 18 to 21 (inc)
Observations for Month 6 are presented in Appendix 5.6.

Assessment.
An observation for this category from week 18 comments on the students' responses when their End of Term 2 tests are returned to them. By highlighting Group 4's results I was elevating the level of success of the whole class. Rewards such as praise "are almost always effective reinforcers when used properly" (Chance, 1993, p. 789). Group 4 were perceived as our 'weakest' academic group so if they had achieved a 'personal best' then we could all take some credit for their improvement. Our collective success was praised as was the individual success of our highest scorer, Hillary. Our collective valued the group and the individual.

Group Work ethic / process.
In the observations for this category from week 19 we can see individual work and, when the concepts become more difficult, we see a greater role for group work. These work patterns reflect movement within the students' 'zones of proximal development'.
The students' "independence" (Brown, 1994, p. 7) was reflected in their individual work which illustrated working on concepts that fall within their actual developmental levels. However, when the work moved towards the students' potential developmental level, they collaborated with their peers to ensure continued progress and success. The students' group work facilitated the movement of concepts through their proximal 'zones', from their potential developmental level to their actual developmental level.

"What lies in the zone of proximal development at one stage is realised and moves to the level of actual development at a second. In other words, what the child is able to do in collaboration today he will be able to do independently tomorrow" (Vygotsky, 1987, p. 211).
The observation below reflects a specific instance of our observing the dynamics of the students' 'zones of proximal development'.

20C - The teacher and the school's Learning Centre support teacher discussed how the students (Group 3, especially Isobel, was the focus) could do the work when helped or guided but were not yet able to reproduce it individually. That is, group work at the proximal level was successful however the students' individual efforts, working at their actual levels, were not yet as successful.
A further set of observations for this category from week 19 highlight how the class had developed the social norm of allowing everyone a turn in a discussion. The class is often influenced by such student-determined control measures, for such is the model of a collaborative environment. It is also important that group members know that they are individually responsible for their level of understanding of concepts, for they cannot always be carried by others.

Through "increasing autonomy" the students developed their reflective skills, thinking skills, collaborative skills and work management skills, all of which related to gaining greater "responsibility for their own learning" (CC, 1998, p. 36). This was the "individual accountability" aspect of a collaborative environment which Johnson and Johnson, (1990, p. 30), described.

Thus the observations from this category show how we do not see task sharing, as each individual is responsibly developing their own solutions. What we do see is subsequent comparisons of solutions. This was indicative of the "positive interdependence" which Johnson and Johnson, (1990, p. 30) also described.

A final group work ethic observation in this category from week 21 notes how some tasks are very group focused while others are not, a factor alluded to earlier in the study. When tasks are group focused, we often need a member of our group to make the process clear to us before we can begin. Having an individual successfully explain the process to her group clearly illustrates the role of dynamic and overlapping 'zones of proximal development', the model promoted by this thesis.

(a) Discussion / Explanation

The observations for this category from week 18 give a perspective of the kaleidoscope of discussion types evident in our collaborative peer interactive classroom learning environment.

They also illustrated how "the teacher is not the only teacher" as the class frequently had several people leading, synthesising, guiding and facilitating the actions of others (Behounek et al., 1988, p. 12). A further week 18 observation in this category provided an illustration of proximal development assisted not by an adult, teacher or peer, but by a teaching resource, piece of equipment or text.

In this category we also observed the students self-starting in lessons, a process we had been seeking throughout this implementation.
Week 19 illustrates how I am still facilitating processes with suggestions, but more often the students retort 'we are already doing that!' Many of us are thinking alike as our overlapping 'zones of proximal development model' suggests we would.

We invoke development of these overlapping 'zones of proximal development' "by causing each other to think about our thinking", to "have ideas and assess our own ideas, ask others to assess our own ideas and examine and discuss the ideas of others" (Goos and Geiger, 1995, July).

(b) Background

The observations from this category reflect quite positively on the students’ prior experiences.

As "we need to learn more about how perceptions relate to specific experiences" (Stodolsky et al., 1991, p. 113), my habit of asking the students about their prior experiences helped illuminate each concept and topic we met. This was one of the goals we set ourselves after the first CLES for we were aware that "learning is built on existing knowledge" (CC, 1997, p. 199).

We appear to have succeeded in making the students' prior experiences more overt.

The students would "explain, for example, how they and others use mathematics in regulating their lives" (CC, 1997, p. 175) and they would discuss and "model relationships from their own daily experiences" (CC, 1997, p. 194), all of which enhanced the foundation for our work. Even Denise, our most 'individualistic' class member, made a contribution. Our collaborative peer interactive classroom learning environment is winning her over.

As we work through the activities, it is necessary to incorporate the students' experiences into the new techniques we, as a class, are developing. In doing so we are allowing the students' 'everyday' concepts to evolve into the 'scientific' concepts of the instruction they are encountering. Students need to talk and discuss what they know of a concept so they can represent a new idea within their own experiences and hence come to understand the concept more clearly or at a higher level.

"The Vygotskian teacher will devise various ways of achieving this" and will "put a good deal of energy and teaching strategy into closing the gap between the everyday and scientific concepts" (Boomer, 1986, p. 4).
(c) Noise
The usual noise pattern of quiet initial engagement and increasing noise as a task progresses is evident in the observations from this category. We see that some events, such as the end of discussion or questioning, often lead to decreased noise levels. One exception, noted in the observations for this category, is when the discussion was about a difficult concept that the teacher needed to explain. Such discussions are usually followed by the noise of students consulting in their groups as they collectively interpret the new knowledge. Interestingly, quiet is indicative of difficult work not yet understood while noise often represents the process of understanding difficult work. The observations from this category again reflect my delineation between 'productive' and 'disruptive' noise. In week 19, I allow the noise for I perceive it as 'productive' while in week 20 I keep the noise in check to maintain productivity within the class. The observations from this category, as to the natural work cycle of the groups being between 20 and 30 minutes, has been made previously. Thus our lessons frequently contain several different sections. The issue of 'time-on-task' raises interesting questions about the length of tests - something to consider for the future.

(d) Observations:
The observations from this category capture the essence of our classroom activity for the four weeks making up Month 6 of our implementation. The features worthy of highlighting from this data include:
- the students correct their work on their own initiative
- individual work time remains important in the collaborative learning sequence
- group sharing follows on from individual work time
  (this is the work pattern we have observed throughout the study)
- the teacher monitors the progress and understandings within each group
- evidence of one student (Narissa) effectively extending a peer (Robyn) into her proximal 'zone'
- the poor functioning evident in Group 5, reduced to only two members. In our environment, a dyad is not as effective as a triad
- the way all groups cycled through discussion and individual work when completing a group-worked test
- the collaborative approach preferred by Group 2 (they usually do things individually).
(e) Month review - Group Work ethic / process

My synthesis of all of the observations dealing with the Group Work ethic / process for Month 6 led me to the following conclusions:

- our collaborative peer interactive classroom learning environment has functioned extremely well this month
- we have reached the highest levels of collaboration to date and we have a very happy, jovial atmosphere in nearly all our lessons
- with decisions to introduce group-worked tests much of the anxiety and associated negative impact of tests on our environment has subsided
- our discussions are mainly in conversational format with everyone who wishes to contribute being allowed to do so
- much of the mathematics being discussed, negotiated and collectively synthesised is coming from the students as they work together to further their mathematical knowledge
- our level of explanation has improved even further with such a range available that all questions can be answered in ways which enhance the understanding of those involved and advance the development of each student
- we are all actively engaged in helping each other
- the work cycle, which the students utilise in each lesson as they go about completing various tasks, remains the same as it has been throughout the study - listen to the instructions; clarify any points; check with group members as to what is to be done; a brief discussion; work individually; discuss processes, techniques, methods and solutions as details are checked; get or give help to group colleagues as required - and then this cycle repeats or broadens to include class discussion of methods and solutions
- we have continued to strengthen areas which we had earlier noted as possible weaknesses in our collaborative activity, such as utilisation of prior knowledge and monitoring student progress in both understanding and task completion
- the control and the shaping of classroom practices by the students is quite evident
- the evidence of the interactions among our overlapping 'zones of proximal development' became more frequent this month. The dynamics of this process was becoming clearer as our collaborative peer interactive classroom learning environment perfected its learning and teaching processes
- we have an excellent tolerance for variety in our mathematical methods and a thoroughness in refining our techniques to produce our taken-as-shared consensus on mathematical processes
- we have a class of 22 teachers, however the role for the 'appointed' teacher still has some clearly defined duties.
Month 6 presents as a very successful, even climactic, month for our collaborative peer interactive classroom learning environment. The observations and associated narratives paint a scene of a happy, collaborative classroom where positive interactions dominate, where discussion and explanation are the norms and where few negative experiences or events remain. We have reached full maturity in our collaborative peer interactive classroom learning environment.

Student support and criticism of each other and the teacher.
Acceptance and utilisation of all responses provided all students with reward or reinforcement or, as the observations from this category show, with guidance as to their errors or misconceptions. "The teacher accepts all answers and solutions in a completely non-evaluative way" (Cobb et al., 1991a, p. 160). Even the students were observed getting in on the act, correcting and even predicting possible errors or misconceptions.

The observations from this category also show how the teacher encourages the students to reflect on their learning. The objective here is to have the students question their processes so as to ensure they are functional in all situations.
Such reflection was not just "asking students to reflect upon what and how they have learned" (EDWA, 1984, p. 7-9) but it was also about testing the limits of what one had learned. This was a skill which the students were still acquiring. Giving the students time to "reflect upon what they have found from their mathematical work, thinking about what did and did not work and why, and how it connects to other mathematical concepts and processes" (CC, 1997, p. 202), was an important practice in our classroom.

An observation from week 20 in this category makes the interesting point of how I was giving positive support and feedback to the students regarding the amount of work they had been able to do instead of my earlier practice of pointing out how much work they had not managed to complete. Evidence of my further advancement as a teacher in our collaborative peer interactive classroom learning environment. We are a collective now and we function well as a team.
Questioning.
The most important quality of questioning observed in Month 6 is the value to the teacher of asking questions. It is through questions that I gain an understanding of what the students know and thus I can better plan the next stages of concept development within a topic. We see the students asking questions and the students answering questions. We also see a student solving a problem for the class when we detect a lack of information in our class solution. Questions that lead to whole-of-class discussion often generate further questions and are frequently answered by the students from other groups who have already discussed the situation. There is certainly a lot of student control over the work we address, and questioning is an excellent vehicle through which the students can participate and contribute. The observations from this category also note how I, as the teacher, fulfill the role of coordinating or leading the class in discussions.

Any collaborative class will find that questions breed questions, and that answers breed questions, so once a teacher establishes questioning as a social norm for the class the richness and quality of discussions, explanations and learning will all increase as a consequence.

Teacher comments and observations.
The first observation in this category, from week 18, alluded to my practice of enhancing student understanding through the use of stories and by association to practical situations. Each of these techniques aimed to form links between the students' "everyday concepts" and the instructional "scientific concepts" presented in the topic (Vygotsky, 1987, p. 167). This process enhanced the instruction that preceded the development of the new concepts. "Instruction is not limited to trailing after development or moving stride for stride along with it. It can move ahead of development, pushing it further and eliciting new formations" (Vygotsky, 1987, p. 198, italics in original). The result was movement of concepts "into the students' proximal zone" (Brown et al., 1983), eventually resulting in transition to the students' actual level of development.

The teacher's movement around the room forms the dominant set of observations from this category. In moving among the groups I am able to acquire additional information regarding the students' progress with the activities and determine their levels of understandings of the concepts.
"Teachers involved in group work with their classes will find that they (the teacher) are moving around the room constantly" (EDWA, 1984, p. 40).
Moving around the room allows the groups quite personal access to me. They can ask questions, check solutions and discuss tasks or other matters of concern to them.
In this I play an important role for it was "one of the teacher's responsibilities to help children learn how to engage in collaborative dialogue about mathematics" (Wood and Yackel, 1990).
My actions are pro-active as well as reactive as the observations from this category highlight, for when I detect a problem which seems to exist across several groups, or which one group has encountered and that may hinder other groups, I am able to address the class to eliminate the potential for this to be a problem to the students. The observations from this category report on this process of addressing the class to take such corrective measures. Thus it is that my moving around the room allows me to monitor the groups and helps me to identify individual, group and classwide 'zones of proximal development'.
The zone of proximal development is characteristic not solely of the child or of the teaching but of the child engaged in collaborative activity within specific social environments. This interdependence of adult and child is central to Vygotskian analysis of instruction (Moll, 1990, p. 11)
Knowledge of the students' 'zones' was important for "if collaboration is to lead to development, interactions should be within the less competent partner's zone of proximal development" (Tudge, 1992, p. 1365).
Also noteworthy in Month 6 was the relative size of the teacher comments and observations section. Quite small for a four week period. Why? The majority of the observations in this category for this month focused on the activity of the students. The teacher was simply not a big factor in the events that shaped the month. This points to the continued successful development of our collaborative peer interactive classroom learning environment. The teacher was fading even further into the background becoming much more the facilitator and much less a transmissionist.
Tape recorder, video recorder and observer.
The week 19 observation from this category was particularly important for our all-girl class. The university colleague who came to observe us at work was a successful university teacher and SHE was a very competent mathematician. She was exalted as a truly inspirational role model to the students. 'Girls can do anything!'

In the next section, we will examine four of the specific events from Month 6, namely a report on the observation of the class by a research colleague, a report on a further video review of a lesson, the results of a special group-worked test and a further report on the observation of the class by a research colleague.

Observer report - week 18

This next section is a report on another visit to our class by a research colleague who came to observe us working and ask questions about particular facets of our collaborative peer interactive classroom learning environment. This report provides us with an alternative perspective and allows issues to be probed to greater depth. The resulting data enhances the rigour of the evidence emerging from this study. A full transcript of the observer's report is presented in Appendix 5.7.

The observer's report is, of itself, a significant narrative of our class at work. Observations from the observer's report worthy of highlighting include:
- lessons appear to be review work when in fact they are new sections of the course - this reflects the way in which prior knowledge is used to build new experiences upon.

For Group 1
- like working in groups - can check the answers
- do the work individually then discuss in their group
- if another subject utilises group work it is of a different type or structure to the collaborative environment used in our mathematics class
- in mathematics you can talk to and help each other
- the group must decide to get teacher help - only ask if no one can figure out what to do.

For Group 5
- like working in group - can talk to each other
- through explanations can help each other understand the work
- occasionally use group work in other subjects
- mathematics uses groups all of the time
- not allowed to work in groups for tests
• teacher is available to give help as required.

For Group 4
• enjoy working in a group - can talk, help each other and discuss answers
• can explain work to each other
• not allowed to help each other in tests
• mathematics is easier when working in groups
• we get more work done
• we ask the teacher for help after we've asked each other
• mathematics is the only subject where we always work in groups.

For Group 2
• require more teacher help on this occasion
• some of the work is hard, some is easy
• like working in groups - can help each other
• don't use group work much in other subjects.

For Group 6
• enjoy working in groups - can talk
• when don't understand something - first ask everyone in the group and then, if necessary, ask the teacher
• only occasionally do we use group work in other subjects
• eventually get our work done - sometimes lazy - other times very busy.

In this session the observer was asked to probe each group to search for evidence of the students helping each other beyond their actual level of knowledge. That is, to find evidence of the students helping each other work in their proximal 'zones'. All of the groups interviewed expressed satisfaction with group work. They detailed their ability to talk, discuss and check answers and help each other as reasons for their preference for working collaboratively. Most groups described getting and giving explanations and help to each other. Thus the students could recognise how they were able to work beyond their own capacities when they work collaboratively. That is they were working in their proximal 'zones'. Our standard group practices were evident: working individually then collaborating; helping each other and discussing problems in the group before asking for teacher help if stuck. Most groups noted that it was only in our mathematics class that group work was extensively utilised. One group claimed that the work was easier and another said that they achieved more by working in groups. Two groups noted how they were not allowed to work in groups for tests. As noted earlier, this reflection led to the practice of having group-worked tests.

The students have detailed many of the positive facets of the operation of our class, providing valuable snapshots of how we
worked as a collective. Our collaborative peer interactive classroom learning environment is functioning successfully.

Figure 18
Group 6: Wendy, Vicky, Stacey and Trudy

Video report - week 19

The video recording provides rich raw data that I use to supplement my fieldnotes and daily observations. My review of each video was further enhanced through discussion with my research colleague who made and reviewed this recording. The lesson recorded was the second on the topic of AREA. We hoped to find evidence of students helping each other and explaining their work to each other - working in their proximal 'zones' - and evidence of collaboration when doing activities. Observations reflecting such evidence are flagged with an asterisk (*) in the transcript and narrative. In addition to my university research colleague doing the video recording, a second university research colleague was in attendance on this day to observe the class in action. Throughout the transcript, and in the narrative which follows, incidents in which this second colleague is involved are described using the name Dr. F, to distinguish her from the colleague making the video recording. He will be referred to as Dr M. A full transcript of my observations from this video is presented in Appendix 5.8.
The video transcript is, of itself, a significant narrative. Observations from the video recording particularly worth re-iterating include:

• the nature of our collaborative environment - working individually and working collaboratively. The mix varies from topic to topic or from task to task
• the movement of the teacher (and Dr. F) around each of the groups
• the teacher (and Dr. F) discussing the tasks with the students
• the students asking questions of the teacher and Dr. F as they move around the room
• * Faye asking Hillary a question and then Hillary, working in Faye's proximal 'zone', discussing the work with her
• * Hillary and Isobel engaging each others proximal 'zones' as they discuss a point
• * Trudy, Stacey and Wendy engaging each others proximal 'zones' as they discuss a problem
• * Amanda asking Denise a question and receiving an explanation as Denise works in Amanda's proximal 'zone'
• * Trudy and Stacey, working in Wendy's proximal 'zone', helping her to work out an answer
• how the teacher never gives away an answer, but prompts the students to discuss their work to determine a preferred solution
• * the teacher using Louise's work to extend Mary into her proximal 'zone' by explaining the method Louise used. Mary's recognition, once it was explained, of the similarity between Louise's method and her own
• the way the students (sometimes) determine what task to work on despite the teacher's recommendations which illustrates how our "classroom processes give students some flexibility in choosing ways of working and encourage them to take responsibility for their own learning" (CC, 1997, p. 202)
• * Denise helping Amanda work in her proximal 'zone' on some problems
• * how Louise advances her actual level of development - exclaims 'Oh!' - as she progresses through her proximal 'zone' while the teacher explains a problem to her
• * Emma working in her proximal 'zone' as Amanda explains some work to her
• Dr. F involved in helping Emma move through her proximal 'zone' as she works with Group 2
• how the class decides that an estimated or approximated answer is acceptable for a particular task
• the teacher's use of a pause to attract the attention of more students
• how the students, especially Group 4, help each other work through a task
• * the teacher extending Denise and Kerry into their proximal 'zones' as he explains a new method to them
• how other students then observe Denise and Kerry to learn what to do
• * Kerry and Denise helping each other consolidate the new skill
• the use of a larger problem to extend the task further into the students' proximal 'zones' and to embrace a broader range of concepts

The observations from the video recording illustrate the nature of our collaborative peer interactive classroom learning environment. There is a wealth of evidence as to the students collaborating and helping each other along with several instances of students working in their proximal 'zones' aided by their peers or the teacher. Our happy collaborative approach to our work is clearly evident as are the behaviours in class of myself and the students. The observations, from this lesson, further the warrant for our belief in the success of this implementation.

**Special Group-Worked test results - week 20**

Table 17 overleaf presents the individual and group average results for a special group-worked test which was administered during week 20. This test assessed the work we had most recently covered in the Algebra topic on Table, Graphs and Rules plus the Arithmetic topic involving the further manipulation of decimals.

I had previously agreed that I would design any test, which was a class-based test and not a year-based common task, as a group-worked test. This test was the first such test for our class and was written to match the standards of previous, similar assessments. Thus the students had not previously seen any of the questions. The students participated enthusiastically in this assessment. The results ranged from 65% for Group 4 to 100% for Group 1 with a class average of 82.5%, our highest class average ever! From a class perspective these results were a great boost to everyone's confidence and thus quite useful as the term drew to a close.

Four of the groups improved their result over the previous test. They were Groups 1, 2, 3 and 5. Groups 4 and 6 saw small declines in their group results. This may have reflected the fact that this test followed along the lines of most other tests in that the students had not seen the material prior to the assessment. The previous group-worked assessment was in fact a second attempt for the students at the End of Term 2 test, that is they had seen that test before.
Table 17  
Special Group-Worked test results  
(individual and group average)

<table>
<thead>
<tr>
<th>Group</th>
<th>Name</th>
<th>Special Group-Worked test result %</th>
<th>Group average %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Betty</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Jenny</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Cathy</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>2</td>
<td>Emma</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Denise</td>
<td>80</td>
<td></td>
</tr>
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<td>2</td>
<td>Amanda</td>
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<td>3</td>
<td>Hillary</td>
<td>92.6</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Gwen</td>
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<td></td>
</tr>
<tr>
<td>3</td>
<td>Faye</td>
<td>92.6</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Isobel</td>
<td>92.6</td>
<td>92.6</td>
</tr>
<tr>
<td>4</td>
<td>Mary</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Kerry</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Yvonne</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Louise</td>
<td>65</td>
<td>65</td>
</tr>
<tr>
<td>5</td>
<td>Robyn</td>
<td>81.5</td>
<td></td>
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<td>5</td>
<td>Narissa</td>
<td>81.5</td>
<td></td>
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<tr>
<td>5</td>
<td>Penny</td>
<td>81.5</td>
<td>81.5</td>
</tr>
<tr>
<td>6</td>
<td>Stacey</td>
<td>76</td>
<td></td>
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<tr>
<td>6</td>
<td>Trudy</td>
<td>76</td>
<td></td>
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<tr>
<td>6</td>
<td>Wendy</td>
<td>76</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Vicky</td>
<td>76</td>
<td></td>
</tr>
</tbody>
</table>

Regardless of the size of increase or decrease the numbers themselves were very pleasing to the students. Each had a score of which she was very proud, and all but two (Yvonne and Stacey) had a personal best score for the term.

It was my perception that collectively, we viewed group-worked tests as a success - a good thing - a rare endorsement for mathematics assessments (Research Advisory Committee of the NCTM, 1988, p. 343). Certainly all future (Semester 2) class-based tests would be group-worked.
Observer report - week 21

The final report in this section is on another visit to our class by a research colleague who came to observe us working and ask questions about particular aspects of our collaborative peer interactive classroom learning environment. This report provides us with an alternative perspective and allows issues to be probed to greater depth. The resulting data enhances the rigour of the evidence emerging from this study. This session was a follow-up to the session earlier in the month (week 18). The questions remained similar in purpose, that is the observer was asked to probe for evidence of the students giving or receiving help and engaging each other beyond their actual levels of knowledge, to find evidence of helping each other work in their proximal 'zones'. In addition, the observer endeavoured to contact each of the seven students who were missed in the previous session. In this she was successful, as all seven were interviewed during this session. The interviews took the form of the observer talking to pairs of girls at a table separated from their groups, thus allowing the rest of us to get on with our work. A full transcript of the observer's report is presented in Appendix 5.9.

The observer's report is, of itself, a significant narrative of our classes perspectives. Observations from the observer's report worthy of highlighting include:

- teacher demonstration and explanation of equipment to be used
- mathematics is the only class where group work is always used
- when you can't do a problem the rest of the group helps you
- can still ask the teacher for help if need to
- the work was within the prior experience range of some of the students
- the work was not within the prior experience range of some of the students

The interviews changed their focus after the first couple of pairs because, as the observations from the observer's report note, the students felt pressed for time and were keen to keep the interview short so they could get back to their experiments and finish the tasks. The teacher, (yes I), was to blame for this as I was continuously reminding the students to hurry through these tasks during the lesson. I was responsible for a subsequent decline in the quality of the observations in this report. The observer also made the valid comment, post-interviews, that the students may not remember the less exciting tasks associated with this work. Thus the students' recollections may be 'selective' in that they only recall 'exciting' mathematics. Now there was a challenge. This data adds to that collected earlier this month, and as such furthers the case for supporting our belief that this collaborative peer interactive
classroom learning environment has evolved successfully after six months of operation.

**Disconfirming Evidence**
During Months 4, 5 and 6 some instances of disconfirming evidence were recorded and noted in the observations, vignettes and associated narratives. This evidence is further highlighted below, in summary form, to exemplify possible limitations in the implementation. Limitations are discussed in Chapter 5.

- some discussions, lively debates, cannot be resolved
- prior experience advantages some students or groups over others
- students became interested in re-grouping
- students’ prior experiences still need to be highlighted
- Group 4 has low self esteem and lacks the confidence to get on with the work without the support of the teacher
- the work is becoming increasingly difficult
- we don’t always get along
- we don’t like tests which have to be worked individually – we like group-worked tests
- students still work as individuals – can’t collaborate 100% of the time
- students need to be aware of their individual responsibility for their level of understanding of concepts
- some tasks are not suited to collaborative group work
- the teacher is still facilitating processes with suggestions
- do student ‘time-on-task’ abilities have implications for the length of assessments?
- dyads function less effectively than groups of three or four, in our environment
- students are still learning about the need to test, and how to test, the limits of their knowledge
- class-based tests are not year-based common tasks and thus lack a comparative performance base (class-based results are standardised against the common tasks at the end of the semester)
- lesson activities inhibit complete engagement by the colleague observer
- students' recall is 'selective', focusing on the most memorable moments in class.
Term Two assessment review

This next section presents a summary of the students' non-test assessment scores for Term 2. As the semester grades were determined mid-way through Term 2, only those non-test items contributing to the Semester result are included here. The remaining non-test assessments from Term 2 contribute to the Term 3 non-test score. For the first part of Term 2 each student obtained a score for the non-test items listed in Table 18 presented below.

**Table 18**

Term 2 non-test assessment items

<table>
<thead>
<tr>
<th>NAME OF ITEM</th>
<th>Value scored out of</th>
<th>Value as a percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homework 1</td>
<td>2</td>
<td>3.0</td>
</tr>
<tr>
<td>Chapter 4 quiz</td>
<td>5</td>
<td>7.6</td>
</tr>
<tr>
<td><em>Meas</em>(length) grp score</td>
<td>20</td>
<td>30.3</td>
</tr>
<tr>
<td><em>Meas</em> (Area) grp score</td>
<td>23</td>
<td>34.8</td>
</tr>
<tr>
<td>Homework 2</td>
<td>6</td>
<td>9.1</td>
</tr>
<tr>
<td>Quiz</td>
<td>10</td>
<td>15.2</td>
</tr>
<tr>
<td><strong>TOTAL POSSIBLE</strong></td>
<td><strong>66</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

In a change from the Term 1 description, items in italics in Table 18 represent scores which were obtained by the group. Other items were awarded bonus scores based on group performance. Thus the better everyone's effort, the more bonus score everyone stood to gain. In addition, as we revised for the test, which we did individually, it was also possible to collect bonus scores based on one's individual effort on the last two of the assessments listed in Table 18. Of course one gained even more points if one's group also achieved at the higher level, that is one could accrue double bonus points. More incentive to do one's personal best and have some "individual accountability" while working hard to help one's group maintain the "positive interdependence" (Johnson and Johnson, 1990, p. 30) so valued in a collaborative environment such as ours.

The final total non-test score for the term was converted to a percentage and entered into the school data base as the Term 2 teacher mark. A summary of the final Term 2 percentages for each student is given in Table 19 overleaf.
Table 19
Term 2 - Final scores

<table>
<thead>
<tr>
<th>Name</th>
<th>Group</th>
<th>Teacher Mark</th>
<th>Mid-Term 2 test</th>
<th>End of Term 2 test</th>
</tr>
</thead>
<tbody>
<tr>
<td>Betty</td>
<td>1</td>
<td>82</td>
<td>80</td>
<td>68</td>
</tr>
<tr>
<td>Jenny</td>
<td>1</td>
<td>85</td>
<td>41</td>
<td>64</td>
</tr>
<tr>
<td>Cathy</td>
<td>1</td>
<td>92</td>
<td>85</td>
<td>58</td>
</tr>
<tr>
<td>Emma</td>
<td>2</td>
<td>85</td>
<td>37</td>
<td>55</td>
</tr>
<tr>
<td>Denise</td>
<td>2</td>
<td>80</td>
<td>54</td>
<td>69</td>
</tr>
<tr>
<td>Amanda</td>
<td>2</td>
<td>86</td>
<td>61</td>
<td>62</td>
</tr>
<tr>
<td>Hillary</td>
<td>3</td>
<td>94</td>
<td>80</td>
<td>79</td>
</tr>
<tr>
<td>Gwen</td>
<td>3</td>
<td>88</td>
<td>50</td>
<td>49</td>
</tr>
<tr>
<td>Faye</td>
<td>3</td>
<td>88</td>
<td>26</td>
<td>29</td>
</tr>
<tr>
<td>Isobel</td>
<td>3</td>
<td>94</td>
<td>74</td>
<td>71</td>
</tr>
<tr>
<td>Mary</td>
<td>4</td>
<td>70</td>
<td>56</td>
<td>52</td>
</tr>
<tr>
<td>Kerry</td>
<td>4</td>
<td>80</td>
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<tr>
<td>Yvonne</td>
<td>4</td>
<td>79</td>
<td>74</td>
<td>63</td>
</tr>
<tr>
<td>Louise</td>
<td>4</td>
<td>79</td>
<td>43</td>
<td>42</td>
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<tr>
<td>Robyn</td>
<td>5</td>
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<tr>
<td>Narissa</td>
<td>5</td>
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<td>80</td>
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<tr>
<td>Penny</td>
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<tr>
<td>Stacey</td>
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<td>65</td>
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<td>Trudy</td>
<td>6</td>
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<td>44</td>
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<td>Wendy</td>
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<td>53</td>
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<tr>
<td>Vicky</td>
<td>6</td>
<td>68</td>
<td>65</td>
<td>55</td>
</tr>
</tbody>
</table>

A complete analysis of results for the semester, the point at which grading occurs, is given in the next section. The following observations offer brief comment on these results at this stage.

- Hillary, Isobel, Betty, Cathy, Yvonne, Stacey and Narissa achieved very good results in the tests this term.
- Denise, Amanda, Penny, Wendy and Vicky achieved good results in the tests this term.
- Mary and Kerry achieved satisfactory results in the tests this term.
- Jenny, Emma, Gwen and Trudy achieved mixed success with their assessments this term.
- Faye, Louise and Robyn struggled with test assessments this term.
**Semester One assessment review**

Table 20 overleaf represents the union of Table 13, Term 1 final scores, and Table 19, Term 2 final scores, extended to show the calculation of each student's final semester score and her resulting semester grade.

The test total is simply the average score from the four tests while the non-test raw total is the average score from the two teacher marks. The non-test raw component is then standardised against the test total. The final semester total is the rounded average of the test total and the standardised non-test total. The grade cut-offs were determined by the Head of the Mathematics Department.

Table 21, two pages over, presents the final semester total, the semester grade, the group semester average, the group rank and each student's individual rank.

From this table we can see that the two top scorers in our class were Hillary and Cathy. These two students were promoted to one of the more able classes for Semester 2. Our class gained a student, Rosie, from one of the more able classes for Semester 2 and our groups were restructured for the start of Semester 2. These results also highlight some other interesting points. We can see confirmation of many of the observations we made throughout the first six months of this study.

These were observations which related to the relative academic merits of the groups. We clearly had a strong group, Group 1, where each member ranked in the top six of our class. We also had a weak group, Group 4. Of this group, Yvonne, and to some extent Kerry, were able mathematicians, but they are still in the lower half of our class. Other observations show Group 3 ranking second thanks to the strong efforts of Hillary (top of class) and Isobel (third in class). The other three groups, Group 2, Group 5 and Group 6, all have group averages within two percent of each other and these students represent the core of our class. Denise and Amanda obtained good results in Group 2, Narissa and Penny performed well in Group 5 and Stacey outperformed her Group 6 colleagues. Upon forming these groups I noted the potential ability of Group 6 as being stronger, on paper, than the other groups. The learning support teacher commented at the time that she was aware of other factors which did not support this observation. These final results indicate that her information was accurate.
<table>
<thead>
<tr>
<th>Name</th>
<th>Group</th>
<th>Term 1 Teacher Mark</th>
<th>Mid-Term 1 test mark</th>
<th>End-of-Term 1 test mark</th>
<th>Term 2 Teacher Mark</th>
<th>Mid-Term 2 test mark</th>
<th>End-of-Term 2 test mark</th>
<th>Test Total</th>
<th>Non-Test Raw Total</th>
<th>Non-Test Standardised Total</th>
<th>SEMESTER TOTAL</th>
<th>SEMESTER GRADE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Betty</td>
<td>1</td>
<td>76</td>
<td>79</td>
<td>91</td>
<td>82</td>
<td>80</td>
<td>68</td>
<td>80</td>
<td>79</td>
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</tr>
<tr>
<td>Jenny</td>
<td>1</td>
<td>72</td>
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<td>89</td>
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<td>64</td>
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</tr>
<tr>
<td>Cathy</td>
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<td>Trudy</td>
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<td>70</td>
<td>68</td>
<td>51</td>
<td>61</td>
<td>B</td>
</tr>
</tbody>
</table>
Our class average for the semester was 62.8%. This result was higher than the End of Term 1 test, the Mid-Term 2 test and the End of Term 2 test. It was lower than our Mid-Term 1 test average and our two group-worked test averages. Compared to the other five classes, our result ranked us fourth out of six (including the two 'top stream' classes).

Table 21
Semester 1 class results

<table>
<thead>
<tr>
<th>Name</th>
<th>Group</th>
<th>SEMESTER TOTAL</th>
<th>SEMESTER GRADE</th>
<th>Group Averages</th>
<th>Group Rank</th>
<th>Individual Rank</th>
</tr>
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<tbody>
<tr>
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<td>76</td>
<td>B</td>
<td>79</td>
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<tr>
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<td>B</td>
<td>79</td>
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<tr>
<td>Cathy</td>
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<td>A</td>
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<td>C</td>
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<tr>
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<td>C</td>
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<td>C</td>
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<td>D</td>
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<td>B</td>
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</tbody>
</table>

The other five classes had averages of 83%, 82%, 67%, 61% and 55%. The year average was 68.5%. Thus our class was just 5.7% below the year average. This was our closest result for the semester, as our End of Term 1 and End of Term 2 averages were 13.3% and 7.9% lower than the respective year cohort averages. We were gaining on them, and when one 'factored in' the non-test components, we were now
only 5.7% behind on average. Even on the basis of this 'primitive' comparison there was evidence of a positive contribution to our results of our working collaboratively.

These results were made known to the students during Month 6. The class consensus, as I perceived it, was that working collaboratively was the students' favoured option for the study of mathematics. The semester results helped highlight further benefits from working in groups. As our earlier research had shown, through my observations and those of the research colleagues observing our class, conducting interviews and making video recordings, the students had developed an effective and highly functional collaborative peer interactive classroom learning environment in which they approached the study of mathematics positively and with enthusiasm. We all looked forward to next semester with our new group structures helping us to further refine our collaborative learning and teaching practices.
Chapter Summary

This chapter has presented, analysed and interpreted the data collected during the first semester (two terms, six months, 21 weeks) of this implementation. The data consisted of observations, transcripts, reports and results from a wide range of sources including: daily fieldnotes; daily audio recordings of lessons; MCI and CLES learning environment surveys; video recordings of selected lessons; independent observer reports on selected lessons; results from Mid-Term, End of Term and special group-worked tests; Buddy reports; documentation for students; term programmes; weekly lesson schedules; group work in other subjects reports and photographs. The data was accompanied by my vignettes and narratives which explained the observed trends from within our environment and illuminated the many significant highlights evident from the observations, transcripts, reports and results.

The primary observational data arose from my daily fieldnotes and daily audio recordings. This data was categorised as follows:

- S category observations were those which seemed familiar, similar of the SAME as others previously recorded.
- D category observations were those which appeared DIFFERENT from previous observations.
- C category observations were neither S nor D and hence were more like COMMENT type observations pertaining to the classroom learning environment and it's participants.

Appearing throughout my narrative were additional special observations, identified by a number, which represented the week they were recorded during, and one of the above categories; S, D or C. Thus a SAME category observation from Week 7 had the prefix 7S. These additional observations further illustrated the trends outlined in the narrative.

The data was presented month by month for the first three months of the implementation and as highlights from the next three months, the second term of the four term school year. The data was categorised into key areas which remained viable throughout the study. These key areas were: the student document (first principles); marks and assessments; group work ethic / process; our environment; support and criticism; listening skills; questioning skills; teacher comments and observations; tape / video recorder; specific events. The key focus area group work ethic / process was further analysed under the following additional criteria: group
work process; discussion and explanation; background; tasks; noise; behaviour; help; homework; observations. Some focus areas did not appear in each month’s report for it was the nature of the data as observed and analysed that determined what was reported.

Following on from each month’s primary data set came the data and narratives for each specific event (as listed above). These included transcripts, which of themselves represented significant narratives on our environment, and selected highlights from these transcripts, which helped to further illuminate the trends presented by the specific events data. We also had special enrichment of the data in the form of video recordings and observer interviews, compiled with the assistance of research colleagues.

Finally, the chapter included a review of Term 1, focusing on the study’s methodology, and a report on the Term 1 assessment results, which appeared at the conclusion of the report on Month 3. Following on from the report on the second term we had a report on the Term 2 assessment results, the semester marks analysis and final grading process, and this chapter summary.

It has been a long but fascinating journey. The students and I have learned a great deal and are 'changed' for the experience. Ahead, we have the excitement of new group structures and new mathematics to learn as we face Term 3. For the reader however, it is now time to conclude this study.

The final chapter will examine the research questions posed when this study was formulated, draw some conclusions and outline the implications arising from our journey. In summarising the study we will examine the limitations we encountered along the way, and weigh up the evidence to establish a warrant as to the success or otherwise of the implementation of our collaborative peer interactive classroom learning environment.
CHAPTER 5

SUMMARY FINDINGS, RESEARCH CONCLUSIONS, LIMITATIONS, IMPLICATIONS and RECOMMENDATIONS

Introduction

This chapter contains the summary of my findings from the implementation, the conclusions relating to the research questions posed in Chapter 1, a review of the limitations encountered in this research, and a statement of implications and recommendations arising from the study. In previous chapters I have presented the literature pertinent to this study from the fields of mathematics education, collaborative group work, Vygotskian developmental theory, constructivist pedagogy and learning environment research, all of which formed the multiple theoretical perspectives framing the implementation. Also presented was the methodological design for the study, involving a teacher-as-researcher ethnographic perspective, and the narrative (or highlights) of the observational data collected during the first semester (six months or twenty one weeks) of this implementation.

SUMMARY FINDINGS

In this section I will present the findings of greatest significance from the implementation.

Assessment

Assessment impacted heavily on the development of our collaborative peer interactive classroom learning environment. Over the semester we evolved from tests which focused on the individual, to tests worked by the group. The development of group-worked tests highlighted my balance between developing genuine collaboration and assessing the individual.

- Our class average for the special group-worked test we completed in Term 2, 82.5%, was our highest test result for the semester.
- Our class average for the semester, 62.8%, ranked us fourth out of the six classes (including the two 'top stream' classes). The other five classes obtained averages of 83%, 82%, 67%, 61% and
55%. The year average was 68.5%. Thus our class was just 5.7% below the year average, our closest result for the semester.

Reviewing our results over the semester demonstrated continuing improvement in our assessments and provided excellent evidence of the positive contribution made by the collaborative peer interactive classroom learning environment to our individual and collective results.

**Work Cycle**
A significant outcome from this implementation related to the observations of the work cycle which developed in our collaborative workplace. The cycle was observed early in the first month and continued to be observed in subsequent months as the following highlights indicate.

- Month 2 - the work pattern established in the first month remained functional throughout Month 2 and we learned that continuous work periods need to be less than 30 minutes in duration to be effective to learning.
- Month 5 - our work cycle continues in the form it has held since Month 1 - attention to instruction, questions for clarity, discussion within groups, individual working and more group discussion and checking - this pattern then oscillates through quiet working, discussing the methods / solutions and the giving or receiving of help.
- Month 6 - the observations as to the natural work cycle of the groups being between 20 and 30 minutes has been made previously. Thus our lessons frequently contained several different sections. The issue of 'time-on-task' raises interesting questions about the length of tests - something to consider for the future.
- Month 6 - individual work time remains important in the collaborative learning sequence. Group sharing follows on from individual work time.

These highlights also described the finding that, within the work cycle, the groups exhibited functional 'on-task' periods of 20 to 30 minutes. Consequently, lessons evolved to contain a variety of tasks. Also evident was the importance of time within the group work cycle for individuals to focus on their work.
Individual = Group
More recent perspectives on collaboration, (Brown, 1994), have seen the emergence
of the individual as a significant part of the collective as he or she jointly functions
within society. This trend was also evident among the observations from this
implementation as the following highlights illustrate.

- Month 1 - even when working individually the students still
discuss their work. The individual models the collective.
- Month 1 review - Group Work ethic - I believe these observations
make a strong case for how a group's functions parallel that which
I had previously observed as individual functions. So we can see
how our functional collective acts / reacts in much the same way
as does an individual. The better the functioning of a group, the
more like an individual it (the group) becomes.
- Month 6 - our collective values the group and the individual, for
when groups improve so do individuals, and when individuals
improve so do groups.

That the group models the individual was a significant finding from this
implementation. We saw students taking individual responsibility for developing
their solutions which, according to Johnson and Johnson, is indicative of the
"individual accountability" aspect of a collaborative environment, and we saw
subsequent discussion and comparisons of solutions which reflects "positive
interdependence", also described by Johnson and Johnson, (1990, p. 30).

Noise
Several findings arose from my observations about the noise in our classroom. As
the highlights below note, the passive process of actively listening, and the many
forms of noise we observed, all reflected learning in progress in our collaborative
peer interactive classroom learning environment.

- Month 2 - our collaborative learning environment provides the
students with frequent opportunities to enhance their learning by
actively listening to others. Time does not always allow everyone
an opportunity to have a say, but such occurrences need not
disadvantage one's learning. This apparently passive behaviour
highlights a significant benefit which the students gained from our
collaborative peer interactive classroom learning environment. We
observed this behaviour on several occasions. Students were busy
learning by listening to others. Peterson and Swing (1985) found a significant positive relationship between listening to others' discussion and achievement as did Webb (1991) who commented that "students can benefit from observing the interaction in the group, not only by actively interacting themselves" (Webb, 1991, p. 377). One need not actively participate in the group to gain benefit from group work because listening or monitoring is an 'active' form of participation.

Recognition of this phenomenon provided a new perspective on the discourse within our class.

- Month 3 - gave rise to a new phenomena which, although previously observed, had not been easily identified or categorised - loud and multi-voiced 'class noise' types of discussions. This works in a most surprising way. The situation is similar to that in which two people, engaged in conversation, are both simultaneously talking and listening. Most people can effectively communicate in this fashion. In our class we have groups of three or four individuals who all simultaneously engage in listening and talking. This multi-voiced discussion is very effective and can examine and resolve matters of interest or concern to the group quite rapidly. Watching students at play in their break times revealed to me that such practice, multi-voiced discussion, is quite a common social skill among their cohort.

It was indeed an endorsement of the success of this implementation that these social skills made a successful transition into our collaborative peer interactive classroom learning environment.

Another significant finding relating to noise in the classroom involved the observed cycle of noise accompanying group work activity, as these next highlights recall.

- Month 6 - the usual noise pattern of quiet initial engagement and increasing noise as a task progresses is evident in the observations. Events such as the end of discussion or questioning lead to decreased noise levels. While noise represents the process of understanding difficult work it is interesting to note that lack of noise is sometimes indicative of difficult work not yet understood, for example when the discussion is about a difficult concept. Once an explanation is explicated the noise returns as the
students consult within their groups and collectively interpret the new knowledge.

Noise arises from discussion, and discussion had many forms as we observed.
- Month 6 - week 18 - gives a perspective of the kaleidoscope of discussion types evident in our collaborative environment.
- Month 6 - week 19 - the class has developed the social norm of allowing everyone a turn in a discussion.

It is significant that we frequently saw a mix of students leading, synthesising, guiding and facilitating the actions of others for this illustrates how "the teacher is not the only teacher" (Behounek et al., 1988, p. 12). The class was often influenced by such student-determined control measures, for these sat well with our model of a collaborative environment.

Questions and Answers
Several benefits emerged from our collaborative environment with regard to the development and enhancement of the students' and the teacher's questioning skills, as these next recollections highlight.

- Month 6 - the teacher accepted and utilised all student responses and provided the necessary reinforcement or guidance if errors or misconceptions were apparent. This is as Cobb, Wood and Yackel predicted, "the teacher accepts all answers and solutions" (Cobb et al., 1991a, p. 160). Even the students are observed getting in on the act, asking questions, answering questions, correcting misconceptions and even predicting possible errors.
- Month 6 - questions that lead to whole-of-class discussion often generate further questions and are frequently answered by students from other groups who have already discussed the situation.

Any collaborative class would find that questions breed questions and that answers also breed questions thus, establishing questioning as a social norm for the class enriched the quality of discussions and explanations which in turn enhanced learning.

The Teacher
Significant evidence emerged from the implementation regarding my advancement as a collaborative learning environment teacher – evidence summarised in the following recollections.
- Month 6 - It is through questions that I gain an understanding of what the students know and thus I can better plan the next stages of concept development within a topic.
- Month 6 - in moving among the groups I am able to acquire additional information regarding the students' progress with the activities and determine their levels of understandings of the concepts.
- Month 6 - moving around the room allows the groups quite personal access to me. They can ask questions, check solutions and discuss tasks or other matters of concern to them.
- Month 6 - I am now giving positive support and feedback to the students regarding the amount of work they have been able to do instead of my earlier practice of pointing out how much work they had not managed to complete.
- Month 6 - I am pro-active as well as reactive - when I detect a problem which seems to exist across several groups, or which one group has encountered and that may hinder other groups, I am able to address the class to eliminate the potential for this to be a problem to all students.

I had developed effective questioning techniques, I maintained close contact with the students as I move around the room, and I maintained an awareness of the need to assist the collective as well as individuals. "As the students are learning mathematics, the teacher is learning about mathematics, learning, teaching, and about the mathematical thinking of their students" (Simon, 1995, p. 141). I was learning, and I had certainly grown as a result of working in this collective.

**Constructivism**

As a referent for this study I moulded constructivism into something applicable to our collaborative environment. I developed my own perspective in which I fused an emergent view and a socio-cultural view into a duality of these conditions, where the community fed-off the individual and the individual fed-off the community. Thus individual and collective processes became mutually mediating. By building up the individual and collective systems into a classroom community culture we could mediate between personal and collective meanings. My role was to "mediate between personal and cultural meanings" (Cobb, Boufi, McClain and Whitenack, 1995, July) as I monitored the "emergence of individual and collective systems". I helped the students "build up towards a cultural community" (Cobb et al., 1995.
July), of mathematicians. This was a significant outcome for our environment and my development as a 'constructivist teacher'.

A further significant finding in terms of the constructivist perspectives included in this implementation related to the value of prior knowledge to our learning environment. As the teacher in this study I frequently framed discussions around the variety of student opinions about concepts, processes and procedures. Not only did this tend to develop into a wider, taken-as-shared mathematical reality, but it simultaneously capitalised on, and valued, student input. It offered students visible evidence of how they were constructing their reality, as individuals and as members of a group or class. The beauty of this approach was that it took into account students' individual differences in prior knowledge, and so gave support to the constructivist notion of building on each individual's background knowledge base. This took time to develop, and we saw several instances of boredom as we worked some activities. Boredom represents work at or below the students' actual level of development and this can be avoided if a greater awareness of students' prior knowledge of the work involved is obtained. This was a challenge we set ourselves early in the study. That we were successful is evident in the data which is recalled in the following highlights.

- **Month 3** - we have seen a significant increase in the use of the students' prior knowledge.
- **Month 6** - we appear to have succeeded in making the students' prior experiences more overt. This was one of the goals we set ourselves after the first CLES.
- **Month 6** - as we work through the activities, it is necessary to incorporate the students' experiences into the new techniques we, as a class, are developing. In doing so we are allowing the students' 'everyday' concepts to evolve into the 'scientific' concepts of the instruction they are encountering. Students need to talk and discuss what they know of a concept so they can represent a new idea within their own experiences and hence come to understand the concept more clearly or at a higher level. "The Vygotskian teacher will devise various ways of achieving this" and will "put a good deal of energy and teaching strategy into closing the gap between the 'everyday' and 'scientific' concepts" (Boomer, 1986, p. 4).

A significant outcome from adoption of a constructivist perspective was that we recognised that "learning is built on existing knowledge" (CC, 1997, p. 199). In
achieving this we evoked an environment more attune with our Vygotskian perspectives - an added bonus.

Vygotsky
Much was made in this study of the importance of the theoretical positions which informed and guided the development and implementation of our collaborative peer interactive classroom learning environment. In embracing a constructivist perspective, this study situated itself within a socio-cultural context for learning which views "the body of mathematical knowledge as being represented by a socio-cultural historical construction" (Schmittau, 1993, p. 33), a position which links a constructivist perspective with a Vygotskian approach. "Vygotsky's strategy was essentially a cooperative learning strategy. Under these circumstances, children could create a 'zone of proximal development' for each other. Vygotsky saw peer interaction as fostering self-regulation, self-direction and self-control" (Newman and Holzman, 1993, p. 77). Thus a clear association formed between Vygotsky's theoretical approach to classroom learning, constructivism's socio-cultural context for learning, and the use of a collaborative classroom environment. The steady increase in the pace and level of difficulty, which was indicative of the mathematics course covered in my study, could also be described in Vygotskian terms as "operating in the zone of proximal development" (Hedegaard, 1990): a Vygotskian environment using collaborative techniques to produce constructivist outcomes. It had all come together.

When the students worked collaboratively, they used their own language and this allowed them to develop 'scientific' concepts using the understanding they already had from their own, or their peers, 'everyday' concepts. By modelling my teaching on a Vygotskian approach I attempted to draw on the students' 'everyday' concepts in much the same way that a 'constructivist teacher' draws upon students' prior knowledge. In our collaborative peer interactive classroom learning environment the students worked together and debated or discussed their ideas and solutions as they attempted a variety of mathematical tasks. The beauty of this approach was that it took into account students' individual differences in prior knowledge, and so gave support to the constructivist notion of building on each individual's background knowledge base.

Summary observations from Week 18 of the teacher comments and observations section in Month 6 referred to my practice of enhancing student understanding through the use of stories, and by association to practical situations. Each of these techniques aimed to form links between the students' 'everyday' concepts and the
instructional 'scientific' concepts presented in the topic. This process enhanced the instruction that preceded the development of the new concepts. "Instruction is not limited to trailing after development or moving stride for stride along with it. It can move ahead of development, pushing it further and eliciting new formations" (Vygotsky, 1987, p. 198, italics in original). The outcome was movement of the concepts further "into the students' proximal zone" (Brown et al., 1983), eventually resulting in transition to the students' actual level of development. Instruction embraced prior knowledge and facilitated the transition of 'everyday' concepts into 'scientific' concepts and visa versa. The resulting movement of concepts through the student's 'zone of proximal development' enhanced the student's development and understanding of these concepts.

One finding from this study, reflected in the analysis of the progress various students made in their assessments, was that by collaborating, each individual enhanced his or her personal progress. Vygotsky's investigations into learning and development recognised the importance of having students work collaboratively.

An essential feature of learning is that it creates the zone of proximal development; learning awakens a variety of internal developmental processes that are able to operate only when the child is interacting with people in his environment and in cooperation with his peers (Vygotsky, 1978, p. 90).

Vygotsky deemed it as necessary that students interact and collaborate. Thus it was that in our classroom I, as the teacher, focused on providing a learning environment which facilitated the collaborative endeavours of the students to enhance the development of each individual. Learning created the 'zone of proximal development', and this became a vital feature of our collaborative peer interactive classroom learning environment.

We should think of the zone of proximal development as characteristic not solely of the child or of the teaching but of the child engaged in collaborative activity within specific social environments. The focus is on the social system within which we hope children learn, with the understanding that this social system is mutually and actively created by teacher and students. This interdependence of adult and child is central to Vygotskian analysis of instruction (Moll, 1990, p. 11).

In our classroom, I endeavoured to link the students' instruction to their prior knowledge and experiences of the concepts being studied. Thus 'scientific' concepts were linked to 'everyday' concepts across each student's 'zone of proximal
development'. As the students worked collaboratively to develop their understanding of these concepts, the 'scientific' became the 'everyday' and the 'everyday' became 'scientific'.

What lies in the zone of proximal development at one stage is realised and moves to the level of actual development at a second. In other words, what the child is able to do in collaboration today he will be able to do independently tomorrow (Vygotsky, 1987, p. 211). The students' 'zones of proximal development' determined the domain of transitions that were accessible to them in collaboration. These findings supported Vygotsky's determination of the role of the 'zone of proximal development' as the "defining feature of the relationship between instruction and development" (Vygotsky, 1987, p. 211). It was significant that these findings arose in a natural collaborative classroom context, for Vygotsky formulated his theory about the 'zone of proximal development' in his research on learning and development "at school age" (Vygotsky, 1963. p. 31).

The findings of this study also bind together the points made by Vygotsky (1987), Brown (1994), Moll (1990) and Elbers, Maier, Hoekstra and Hoogstede (1992) about collaborative activity within the classroom social system awakening development within 'zones of proximal development'. When located in a classroom context this suggested an amendment of Wertsch's (1979) interpretation of internalisation, (internal developmental processes), which he described as movement from "other regulation" to "self regulation". The findings from my study provided support for Elbers, Maier, Hoekstra and Hoogstede's (1992, p. 115) description of internalisation as movement from "joint regulation" to "self regulation". This interpretation emphasised the social nature of the students initial contact with new concepts and clarified the process of internalising or making these concepts one's own.

'Zones of proximal development' are not static, they are highly dynamic, and as such each student moves through, forwards, backwards and within their 'zone of proximal development' when working in collaboration with their peers. Observations from the video and independent observer reports (Months 4 and 6) highlighted many instances of the students and groups working across and through their dynamic classwide and individual 'zones of proximal development'. In particular, this study provided strong supporting evidence for the notion of a collective (group or classwide) 'zone of proximal development'.
Many of the researchers mentioned in this study hint at a wider interpretation of Vygotsky's 'zone of proximal development' principle than they or others have applied. Pontecorvo (1990) and Hedegaard (1990) in particular address the idea of a classwide 'zone of proximal development' and suggest that this comes closest to a practical school based application of Vygotsky's 'zone of proximal development' principle. I believe the findings from my study revealed an even more suitable model for the practical application of Vygotsky's 'zone of proximal development' principle to school based classroom situations. The key to this more practical application of Vygotsky's concept was in considering the 'zone of proximal development' as a dynamic entity which was in a constant state of flux, a 'floating' 'zone'. Observations from Month 2 noted how there were certain times in our lessons when we did not need to work collaboratively. The narrative comments that these observations reflected reverse movement within our collective 'zones of proximal development'. Since our collective 'zones of proximal development' were dynamic entities they facilitated two way movement of development and working individually reflected movement back towards one's actual developmental level.

In this implementation we developed the model of each individual having a dynamic 'zone of proximal development'. When placed in a collaborative peer interactive classroom learning environment, these individuals formed collectives with dynamic overlapping (multiple) 'zones of proximal development'. When taken as a whole, we formed our classwide dynamic 'zone of proximal development'. As early as Week 3 of this implementation we saw evidence of this model in our observations as the extract below highlights.

- The proximal 'zone' is open. Student led discussion resolves student concerns about a task and its solution. This is strong evidence of, and support for, our overlapping (multiple) 'zones of proximal development' model.

Since 'zones of proximal development' were dynamic and continually changing, dynamic overlapping (multiple) 'zones of proximal development' were but a 'snapshot', frozen in time, of the dynamic reality.

In our classroom, the students worked in groups (collectives). By taking a 'snapshot' of their activity we were able to represent the group's dynamic overlapping (multiple) 'zones of proximal development' visually, as shown previously in Figure 1 which illustrated the ideal in a group work context. Each student's 'zone' (S1 - most able to S4 - least able) was overlapped by a more able peer and in the case of the most able student of the group (S1), by the teacher (T), the curriculum, the text, the class collective and so on.
A 'snapshot' of classwide dynamic overlapping (multiple) 'zones of proximal development' was illustrated previously in Figure 4. It is important to emphasise that Figure 4 was a 'snapshot' of a dynamic learning environment. As such any one student, S1, S2, ..., S20, S21, could be located in a different position, relative to their peers, in a previous or subsequent 'snapshot'. Each student's position in the model would vary from topic to topic as a result of their prior experiences and background knowledge, which would vary as different content and contexts are addressed. Indeed, position could change during the time we studied a topic as the concepts moved within, and thus altered, each student's 'zone of proximal development'.

The realisation of this model remained one of the most significant findings of this implementation. By joining together the perspectives of collaboration, constructivism and Vygotsky's 'zone of proximal development' principle, we developed a model for our dynamic, ever-changing collaborative peer interactive classroom learning environment.

The following set of highlights, from the observations made during the implementation, illustrate the significance of this new dynamic overlapping (multiple) 'zones of proximal development' model to our collaborative peer interactive classroom learning environment.

- **The special observation section (Appendix 2.1.7) from Month 1 showed the students working in and through their collective 'zones of proximal development'.**

- **Week 3 observations highlight more evidence of activity within individuals 'zones of proximal development and across the classwide 'zone of proximal development'.**

Collaboration, among peers or between a student and the teacher, advanced the learners' skill and advanced them further through their 'zone of proximal development'.

The next three highlights come from Month 2 of the implementation.

- **The teacher asks the students to define the terms and steps involved in an activity to further clarify the tasks for the class. Thus we are reaching back over the group and individual proximal 'zones' within the classwide 'zone of proximal development'. If the students are still uncertain about the activity, the tasks are modified and brought within the reach of all students. By keeping**
tasks within the classwide proximal level we enhance the potential development of each student.

- The teacher must be the bridge or link across the 'zones' within the classwide 'zone of proximal development'.
- Week 7 - A student asked a question about work we had not yet done but the teacher addressed this within the context of known work and thereby placed the problem within the student's potential. A solution was negotiated as a result.

Working in the proximal 'zone' ensured that instruction led development.

In the student support and criticism of each other and the teacher section, from Month 3, many observations were found to provide strong evidence of students utilising the classwide 'zone of proximal development' to develop their understanding.

For example:

- the students utilised their classwide 'zone of proximal development' to enhance their understanding by building on what they knew and then helping each other extend this, using inputs from several students, until they developed the required knowledge. This represents a very powerful session of student activity in which they developed their new taken-as-shared knowledge by building on their prior experiences.

The students used their classwide dynamic overlapping (multiple) 'zone of proximal development' to take responsibility for their learning.

The reality of working with a class of more than 20 students meant that, regardless of where one posited an activity, it was bound to be below the actual developmental level of some students and above the potential developmental level of other students, and thus not within their existing 'zone of proximal development' (Figures 2 and 3). However, by working collaboratively all students were able to get help, or give help, as their knowledge required or allowed, and thus all benefited from the activity.

- Month 4 - Week 13 - The teacher bridges new ideas from that which the students can do into the next type of problem so they can go on to these. Thus the teacher is building proximal pathways!
- Month 4 - my help for Penny then becomes the subject of group discussion as the ideas and comments are shared.

This was a good example of the dynamics of our model of a classwide 'zone of proximal development'. Teacher assisted student, student assisted other students and so on across the classwide 'zone of proximal development'.
Month 5 - Group 4 have very low self esteem and lack the confidence to get on with the work without support from me. This highlight illustrated the representation of a gap in the 'zones', as shown previously in Figure 3.

Month 6 - These work patterns reflect movement within the students' 'zones of proximal development'. The students' "independence" (Brown, 1994, p. 7) is reflected in their individual work which illustrates working on concepts that fall within their actual developmental levels. However, when the work moves towards the students' potential developmental level they collaborate with their peers to ensure continued progress and success. The students' group work facilitates the movement of concepts through their proximal 'zones', from their potential developmental level to their actual developmental level.

What lies in the zone of proximal development at one stage is realised and moves to the level of actual development at a second. In other words, what the child is able to do in collaboration today he will be able to do independently tomorrow" (Vygotsky, 1987, p. 211).

Month 6 provided the following highlights which reflected instances of our observing the dynamics of the students' 'zones of proximal development'.

- **20C** - The teacher and the school's Learning Centre support teacher discussed how the students (Group 3, especially Isobel, was the focus) could do the work when helped or guided but were not yet able to reproduce it individually. That is, group work at the proximal level was successful however the students' individual efforts, working at their actual levels, were not yet as successful.
- **Month 6** - When tasks are group focused we often need a member of our group to make the process clear to us before we can begin. Having an individual successfully explain the process to her group clearly illustrates the role of dynamic and overlapping 'zones of proximal development', the model promoted by this thesis.
- **Month 6** - Many of us are thinking alike as our overlapping 'zones of proximal development' model suggests we would.

By adopting a Vygotskian perspective for this implementation we were able to combine features from collaboration and constructivism that helped us build a functional and effective collaborative peer interactive mathematics classroom
learning environment. Each theoretical perspective provided valuable support for the development of our classwide dynamic overlapping (multiple) 'zones of proximal development' model for learning in our classroom. The implementation revealed many of the features expected in a collaborative classroom. The observations and assessments provided strong evidence regarding the success of the union of the multiple theoretical frameworks of collaboration, constructivism and especially a Vygotskian approach to learning and teaching.

**Learning Environment Surveys (MCIs)**
The success of this implementation was strongly influenced by the evidence collected during the study. The learning environment surveys, in particular the My Class Inventories (MCIs), played a significant role in painting the picture of our developing collaborative peer interactive classroom learning environment. Research has shown that "students achieved better when there was a higher congruence between the actual classroom environment and that preferred by students" (Fraser and Fisher, 1983a, 1983b). Learning environment measures and this study shared the common purpose of endeavouring to provide a practical way of improving a classroom learning environment. The measures certainly provided valuable feedback as the following observation noted.

- Week 4 saw much more positive progress for our collective. This is the first week after our first MCI!

![Graph](image)

**Figure 19**
'Typical' trends of an MCI class graph in a collaborative peer interactive classroom learning environment
A significant outcome from the implementation, to do with this learning environment measure, was the somewhat stable nature of the MCI results which produced the "\[\text{\texttrademark}\] image on the class data graphs, as shown on the preceding page in Figure 19. I would be interested in seeing if other collaborative peer interactive classroom learning environments produced similar MCI outcomes.

**Other findings**

The following passages represent additional, although less significant, outcomes from this study. Each presents further evidence of the success of this implementation.

From Month 1 of the implementation:
- the students were shaping classroom events as early as Week 1.
- during Week 3 the students were not self starting - by Week 4 they were.
- discussion enhances perspectives which enhances learning.
- for successful collaboration focus the students on one task at a time.
- the students corrected the teacher, thereby diminishing the 'teacher expert' factor.
- having students re-iterate task instructions exposes misinterpretations but also increases language diversity and hence understanding among students.
- the teacher says "I think the answers are ......." - inviting the students to contribute / monitor / check / correct the answers - thus ownership of the discourse and the outcomes is with the students (taken-as-shared knowledge).
- answers reside within oneself or within one's group - the teacher simply facilitates the students' discovery of these answers.
- let the students fill periods of silence in discussion - this encourages and values their contribution.

From Month 2 of the implementation:
- teacher student role reversal occurred in Week 5.
- the teacher explained the role of errors in helping us analyse and learn new concepts.

That students could "make mistakes and do so in front of the class" was a strong sign of the effectiveness of our collaborative peer interactive classroom learning environment (NCTM, 1989, p. 79). We had learned that there was a great deal to
gain by examining our mistakes. "To learn from a challenge or conflict, the student must recognise it and see errors as a useful source of feedback" (CC, 1998, p. 207).

- the teacher accepts and uses all student responses - right or wrong.
- coming to terms with new concepts is often simply a matter of discovering what old concepts can do - this is facilitated by working in the students' 'zones of proximal development'.
- evidence of more student presentations of solutions to tasks.
- the teacher is frequently moving around the room.
- the giving and receiving of help is dominantly a group role now.
- receiving support from one's peers boosts a student's self confidence.
- the students do experience group work in other subjects - though it is not of the same type nor is it in an environment similar to ours.
- the Buddy reports highlighted the collaborative mind set of the students.

From Month 3 of the implementation:

- evidence of strong collaborative behaviours despite reorganising the groups due to camps.
- post camp, the regular groups reformed - excellent revival of collaborative environment and practices!
- student contributions made in one lesson were valued and recalled by the teacher over several of the following lessons.
- the independent observer reported how the students self started upon arrival to class.

By the end of this, our third month, we had endured several negative events - temporarily restructured groups, individual focused tests and lapses into past practices - to emerge with many new collaborative skills and a growing sense of community. We have all benefited from and enriched our collaborative peer interactive classroom learning environment.

Additional, although less significant, outcomes from this study from Months 4, 5 and 6 follow. In particular, my previously presented synthesis of all of the observations dealing with the Group Work ethic / process for Month 6 provided strong support for my claim as to the success of this implementation. The additional passages below represent further evidence in support of my claim.
From Months 4, 5 and 6 (Term 2) of the implementation:

- we have an illustration of proximal development assisted not by an adult, teacher or peer, but by an aid, piece of equipment or text.
- we observed the students self-starting in lessons, a process we have been seeking throughout this implementation.
- even Denise, our most 'individualistic' class member, makes a contribution. Our collaborative peer interactive classroom learning environment is winning her over.
- poor functioning is evident in Group 5, reduced to only two members. In our environment a dyad is not as effective as a triad (threesome)
- reflection is also about testing the limits of what one has learned.
- the relative size of the teacher comments and observations section has diminished - indeed there is very little over a four week period. Why? The majority of the observations this month focus on the activity of the students. The teacher was simply not a big factor in the events that shaped the month. This points to the continued successful development of our collaborative peer interactive classroom learning environment. The teacher transmissionist is fading even further into the background.
- we did more than just sit in groups - we worked as groups (Bennett and Cass, 1990, p. 57).

Which sections of the curriculum were or were not enhanced through the use of a collaborative learning environment? This question was not topic relevant but child relevant and the answer must be interpreted with a student-centred focus.

- skills and consolidation activities are NOT conducive to collaborative activity - these tasks are almost always within each student’s actual developmental level.
- new concepts, extending concepts, modifying concepts or building on old concepts is work which collaboration can enhance - these tasks represent work in the student’s 'zone of proximal development', that is they are at the student’s potential developmental level.

Which learning and teaching methods were effective in collaborative peer interactive classroom learning environments?
• effective methods involve collaborative approaches that: engage in discussion and explanation; make use of prior knowledge; support each other; give and receive help as required; allow people to actively listen; allow people to make, and learn from, mistakes; provide a supportive environment; have groups of three or four people; allow and encourage students to question anything; place the teacher in the background.

All of these characteristics were evident in the observations from this study.

Which assessment practices remained functional in a collaborative peer interactive classroom learning environment?
• NOT individual tests!
• group-worked tests were a better measure of progress.

Monitoring outcomes (CC, 1998) and learning experiences, measuring a student's actual developmental level would also suit such an environment better than tests.

These outcomes conclude my summary presentation of the evidence in support of my belief that we successfully implemented our collaborative peer interactive classroom learning environment.

Methodology

Characteristics of this implementation which strengthened the methodology for this study are highlighted and summarised in the following passages.

This study was classroom-based and was designed to enrich and enlighten more theoretical and laboratory-based forms of research. By examining my own situation I was able to replicate and extend previous studies. "The most valuable way in which existing research can be used is by practising teachers deciding to 'try it and see' within their own school contexts" (Lolley et al., 1987, p. 46). As Stenhouse noted:

It is important to make the point that the teacher in this situation is concerned to understand better his own classroom. Consequently, the teacher need not generalise beyond their experience. In the teacher's context, theory is simply a systematic structuring of their understanding of their work (Stenhouse, 1975, p. 157).

In my study, generalisation meant 'apply what we have learned to different contexts across different times' which is reflected in the potential duplication by others of the ideas in the implementation. "Proving or disproving theories or providing
generalisable results is not necessary. The centrality of the practitioner to the research is seen to provide a much needed emphasis on pedagogical research" (Street, 1986, p. 126). Most of the observations from this study matched the theoretical perspectives upon which the study was based and the study had very explicit and well defined research methods, categories and characteristics. Thus "comparability" and "translatability" (LeCompte and Preissle, 1993, p. 348) were very strong, and comparisons with past or future research could be made which, in turn, delivered an acceptable level of external validity. Also, the study's "procedures are seen to exhibit theoretical (construct) validity" (Kirk and Miller, 1986, p. 22).

Features of the implementation which further strengthened the warrant of the evidence collected in this study included the following:

- multiple data sources consisted of fieldnotes, observations and audio recordings of every lesson, video recordings of some lessons with researcher colleague review of these video recordings, researcher colleague observation fieldnotes and interviews, assessments, learning environment surveys, student worksheets and other artefacts. It was important to have variety of data collection methods to enhance the triangulation of the study.
- rapid review of all data sources and particularly of the audio fieldnotes, within seven hours of each lesson.
- blending techniques of action research and interpretive social science, such as utilising the MCI and CLES learning environment instruments, thus combining qualitative and quantitative approaches. The MCI and CLES provided valuable student feedback which influenced the development of our learning environment.
- using the teacher researcher, two collaborative researchers, and the participants to collect data using several different methods from a variety of sources giving the data multiple perspectives for interpretation - providing adequate triangulation of the collected data.
- presenting 'rich' primary data in the observations enhancing the study's credibility and internal reliability.
- although this study is 'true' only for the time and place of the study, it has more than singular significance since it supports many findings from other studies and could potentially be supported by findings from supplementary studies.
- I ran this implementation for a full six months (one semester) of the school year, for in any ethnographic study "it is critical that observations and interactions with the groups being studied occur over a long duration" (Gallagher, 1984, p. 7).
• A logical generalisation arising from this study suggests that "if the students like the environment and methods used in the intervention then the theory behind such techniques has merit and should be employed on a wider scale" (Patton, 1987, p. 55). I certainly believe that the results of this study endorse the use on a wider scale of the theoretical perspectives underlying our collaborative peer interactive classroom learning environment.

• utilising a strong model of teacher-as-researcher action research with its unique perspective of a teacher immersed in the research setting as a full participant.

• working in a setting where "behaviours occurred naturally", maintaining "constant interaction with participants" (LeCompte and Preissle, 1993, p. 348).

• the improvement and enhancement of my practice in such a way that it will be useful for others as well as myself.

• I have explicated my values, beliefs and the influences of prior work on this study's development.

• the virtually negligible change to the key questions (Figure 6) utilised throughout the implementation.

• the consistency of the monthly data analysis categories (Table 1) which evolved, with only minor changes, throughout the study.

"It seems important to test cooperative methods in ordinary, already existing courses, using simple procedures that could be easily duplicated by other teachers" (Dees, 1991, p. 411). This summed up the methodology I utilised for this study - a methodology which served myself and the students well as we developed our collaborative peer interactive classroom learning environment.
RESEARCH CONCLUSIONS

Aims
In Chapter 1 I summarised the aims of this study as follows:

- develop a functional and effective collaborative peer interactive classroom learning environment and
- examine classroom interactions between the teacher and the students and between the students themselves; to analyse these interactions to inform further improvement of the implemented collaborative peer interactive classroom learning environment.

Of the first there was considerable evidence in the study to support a claim that we achieved this aim. There were repeated and frequent references to my perception, based on the collected evidence, as to the effectiveness and functionality of our collaborative peer interactive classroom learning environment. Therefore I believe the learning environment was successfully established and grew from strength to strength as the semester unfolded. The observations clearly identified the autonomy and empowerment the students achieved within our learning environment. This was another of the aims of this implementation.

Regarding the second aim, there was also considerable evidence in the study to support a claim that it was achieved. The collaborative peer interactive classroom learning environment had been described in great detail. Changes to the students, changes to the teacher, and changes to the environment had all been explicitly detailed. The students' collaborative learning skills were highly developed within the first month of the implementation and continued to improve over the duration of semester one. I believe I was successful in my endeavour to see things from the students' perspectives - the observations reflected the high degree to which this was achieved - another of the study's aims.

Evidence of lapses in the functionality and effectiveness of the environment were reported in the narratives. This negative evidence helped substantiate the warrant supporting my perception of the success of the implementation for it illustrated how the methodology, observations, and analysis remained open to alternative situations, and how the study retained awareness of events counter to the development of our collaborative peer interactive classroom learning environment. In most cases these became the focus of our endeavours and recovery was successfully achieved. A further aim for this study was to link the findings to those of known research. This
occurred frequently throughout the observations and narratives presented in Chapter 4.

The First Research Question
The first research question addressed by this study was:

What specifically is happening in this collaborative peer interactive classroom learning environment?

To answer this question we shall reflect on the significant outcomes arising from this implementation.

- Assessment occurred often in our collaborative peer interactive classroom learning environment: (i) the impact of our environment on the assessments led to the change from tests focused on individual students to group-worked tests. The emergence of group-worked tests was a significant outcome of this implementation; (ii) our test results improved consistently over the semester.

- A work cycle emerged in our daily endeavours and was maintained throughout the implementation. The cycle involved many of the characteristics of a collaborative learning environment including listening, questioning, discussion, individual work, explanation, consensus building, getting help and giving help. We determined that 'on-task' periods of up to half an hour best suited our work cycle.

- The group modelled the individual and the individual modelled the group. The success of our implementation was reflected in how much like an individual each group and the class collective became.

- Noise was a part of our environment. There was a particular noise cycle which matched our observed work cycle. I noted that noise 'correlated' with levels of understanding. The students were also learning by listening as we observed the passive practice of actively listening. The common social skill of loud, multi-voiced discussions also transferred into our collaborative peer interactive classroom learning environment.

- The teacher (I) became quite skilled at accepting all student input and his (my) modelling of this practice led to it being adopted and used openly by the students. A measure of the success of this implementation was seen in the observations of
how our environment embraced questions. Questions bred more questions and even answers bred questions as questioning emerged as a social norm in our collaborative peer interactive classroom learning environment.

- I (the teacher) gained significant skills from my participation in our environment. I focused on the students' prior knowledge; I worked with individuals and groups as well as the class; I shared the teaching load with the students as they frequently took on this role; I learned how to operate effectively within our collaborative peer interactive classroom learning environment.

- Research was happening in our classroom. It was unobtrusive and had the sole purpose of working for our benefit and it never interfered with our learning and teaching. It was helping us achieve our collaborative goals.

- We built up individual and group processes into a classroom community culture from which emerged our collective taken-as-shared mathematical knowledge.

- We valued student opinions about concepts, processes and procedures.

- We enhanced the learning of each individual through our collective collaborative processes.

- We valued each other's prior knowledge and experiences and always endeavoured to build our new understandings on the foundation of our previous experiences.

- We all worked to help each other bridge the gap between our 'everyday' and 'scientific' concepts.

- Our collaborative endeavours enhanced the growth of our individual understandings as we moved from joint regulation to self regulation.

- our learning environment profile was consistent across the monthly MCI measures producing the characteristic ‘\(\wedge\)’ image on our MCI class graphs.

- We endeavoured to close the ‘gaps’ on our MCI measures.

The great detail of what specifically was happening in our collaborative peer interactive classroom learning environment, presented in Chapter 4, summarised in
Chapter 5 and reviewed above, provided a graphic description of the activity in our classroom and of the developments this implementation brought to our learning and teaching environment. The observations noted throughout this thesis point to the most significant outcome of our collaborative peer interactive classroom learning environment. We all changed. We changed because we believed in what we were doing and we detected the advantages that this implementation gave us as individuals and as a collective. We changed and became a successful, effective, functional collaborative peer interactive classroom learning environment.

The Second Research Question
The second research question addressed by this study was:

Does working in a collaborative peer interactive classroom learning environment extend the students into their proximal 'zones'?

To answer this question we shall review the findings of the students working in their proximal 'zones'.

- Working in a collaborative peer interactive classroom learning environment created 'zones of proximal development'.

- In our classroom we observed that when instruction embraced prior knowledge it facilitated linking 'scientific' concepts to 'everyday' concepts across each student's 'zone of proximal development', eventually resulting in movement or enhancement of the student's actual level of development.

- Working collectively reflected movement of concepts towards our potential (proximal) developmental level.

- Working individually reflected movement of concepts towards our actual developmental level.

- Our 'zones of proximal development' were dynamic - concepts moved through, forwards, backwards and within each student's 'zone of proximal development' when he or she worked collaboratively.

- When individuals, each of whom had a dynamic 'zone of proximal development', joined together to form a group, they generated a collective with dynamic overlapping (multiple) 'zones of proximal development'.


• Combining groups, or collectives, formed a class which generated a classwide dynamic 'zone of proximal development'.

• This study provided strong observational evidence for the notion of a collective (group or classwide) 'zone of proximal development', (represented previously in Figure 4). These observations were consistently evident from Week 3 of the implementation.

• Observations from the video and the independent observer reports (Months 4 and 6) highlighted many instances of the students and groups working across and through their dynamic classwide and individual 'zones of proximal development'.

• The following observation extract answers this research question in the affirmative.

  3C – The proximal 'zone' is open. Student-led discussion resolves student concerns about a task and its solution. This is strong evidence of, and support for, our dynamic overlapping (multiple) 'zones of proximal development' model.

• Each student held a different position within our classwide dynamic 'zone of proximal development' model whenever a 'snapshot' was taken. Placement for each student varied from topic to topic and within topics as a result of his or her prior knowledge and recent learning experiences.

• Many observational highlights illustrating the significance of this new dynamic overlapping (multiple) 'zones of proximal development' model to our collaborative peer interactive classroom learning environment were summarised earlier in this chapter. They demonstrated that:
  – collaboration advanced the students further into their 'zones of proximal development';
  – working in the proximal 'zone' ensured that instruction led development;
  – the students used their dynamic overlapping (multiple) 'zones of proximal development' to take responsibility for their learning;
  – activities were not always within every student's 'zone of proximal development', but working collaboratively provided a means of access to understanding the concepts for those students; getting help and giving help benefited all involved.
Does working in a collaborative peer interactive classroom learning environment extend the students into their proximal 'zones'? Yes. The evidence from this study clearly supported an affirmative response to this question. This led me to conclude that Vygotsky's pedagogic approaches were highly suited to, and could be functional in and beneficial to, a collaborative peer interactive classroom learning environment. Indeed, I believe this evidence warrants the adoption of Vygotskian perspectives across a much wider range of educational situations.

Conclusions
A collaborative peer interactive learning environment can function effectively in a high school mathematics classroom such as the one utilised in this implementation. Multiple theoretical perspectives can inform and enhance learning and teaching processes for students and teachers. By adopting a Vygotskian perspective we can utilise a peer interactive environment to develop 'scientific' and 'everyday' concepts through individual, group and classwide 'zones of proximal development'. We can inform, enrich and support the use of collaborative learning in the modern classroom.

Constructivism, especially the focus on prior knowledge and experience, played a significant role in this implementation. Many of our learning experiences were enhanced because of our attention to the students' prior knowledge, because of our attention to the constructivist aspects of our environment. The My Class Inventory (MCI) measures assisted us in our quest to continually improve our collaborative peer interactive classroom learning environment. Each MCI reported our progress and gave us a focus for our endeavours. We treated this 'guidance' quite generally and regarded the MCI as an instrument which pointed us in the right direction rather than specifically identifying weaknesses. The MCI served as a motivational device and the frequency (monthly) of its use matched our needs for encouragement and accountability. Each MCI gave us good news as to our progress and also cautioned us as to the general areas where we could aim to improve further.

This study was very hard work and teachers could do it, but not as a part of regular everyday practice. If such research endeavours were to be undertaken by teachers then the education systems, schools, research community and professional associations would need to support the teacher with guidance, time release and infrastructure that created a 'conducive' teacher-as-researcher environment. I would not recommend the depth and intensity of research in this study to fellow teachers, however I would recommend the collaborative peer interactive classroom learning environment model developed in this implementation.
The methodology for this study served myself and the students very effectively as we developed our collaborative peer interactive classroom learning environment. The factors which assisted in our achievement of establishing a successful outcome included:

- the detailed account which enhanced the opportunity for other researchers to duplicate or make comparisons in their own contexts;
- the many significant links to the research of others that has been made which enhanced the suitability of the teacher-as-researcher action research methodology to this form of inquiry;
- having multiple data sources and observations from collaborating researchers (video and independent observation) which proved essential to the development of the warrant of evidence supporting our claim as to the success of this implementation;
- blending qualitative and quantitative techniques which proved functional and beneficial to this implementation;
- analysing the implementation for a six month period, which allowed all aspects of the emerging collaborative peer interactive classroom learning environment to develop and 'mature' during this time.

In this study the students were positive about the implemented environment. Given the success of the implementation, from the students' and my perspectives, we confidently support the theoretical model upon which our collaborative peer interactive classroom learning environment was founded, and we would recommend wide use of this model. We believe that this study provides a guide to a successful implementation of a collaborative peer interactive classroom learning environment in a high school mathematics class.
LIMITATIONS

Context Limitations
Context limitations related to the constraints placed on this study at the formulation stage when planning the research to be carried out. This was classroom-based research located within the normal functioning of school. At all times, school and teaching requirements took precedence over research requirements and this could be a limitation of this study. Many researchers and teachers would argue that schools and classrooms operating under 'normal' conditions should be where all research is located. I believe that while such research is important, so to are laboratory-based and theoretical types of research. Some of the context limitations we encountered in this study included:

- our class met once a day for about 45 minutes,
- the students attended six other lessons each day and these were not necessarily organised along collaborative learning lines,
- I, the teacher, taught four other classes, none of which were organised into, or operated as, collaborative learning environments,
- the pace of curriculum delivery was set by the school,
- the common year group assessment schedule was set by the school,
- the students in my class were randomly allocated to the class by the school.

These limitations were not seen as restrictive to this study. Rather they helped define who we were and how we operated. In detailing all aspects of the formulation of this study and the context within which this study was set, I have provided adequate grounds from which the warrant of evidence could be collected and from which duplicate studies could be easily designed. A caution must be stated at this point, for a further context limitation applies to duplicate studies. Many cultures, like that of the Australian Aboriginal, or those in the pacific region such as Samoa or Papua New Guinea, have "traditional backgrounds which do not feature cooperative learning forms, making this an 'un-natural' or Western methodology" (Dawe, 1989, p. 13). Researchers must ensure that such cultural requirements are taken into account when designing studies intended to duplicate this particular study.

Action Limitations
Action limitations related to limitations which arose during the implementation phase of this study. Most typically these reflected the significant instances of observations of disconfirming evidence recorded in the data corpus. It could be argued that there were limitations with the data collection procedures I utilised. For
example, there are only a few transcripts of teacher-student discourse, however I believe that the procedures utilised reflected the best possible approach for a teacher-as-researcher action research study. There were several examples in the observations of how the students initiated discussions with the teacher, especially when I was walking around the room. My movement around the room was an action facilitated by the student-centred nature of our learning environment, and yet this action could have introduced the limitation of student questions depending on teacher movement through the room. In fact, questioning was far more extensive than this limitation would suggest.

There may have been times when my work as a teacher inhibited my work as a researcher. Disconfirming observations could be manifest evidence of the teacher-as-researcher dilemma and they could represent limitations within this study. Instances of disconfirming evidence recorded and noted in the observations, vignettes and associated narratives, were reported in Chapter 4 at the end of Month 1, Month 2, Month 3 and Term 2. A summary of the most significant observations from each month, highlighting disconfirming evidence recorded in the data corpus, is presented below to exemplify possible implementation limitations.

Month 1:
- Week 1: I answered the students' questions instead of re-directing the questions back to their groups
- Week 2: Open discussion turns into arguments - not very collaborative!
- Week 3: This teacher led activity is NOT conducive to group work.
- Week 3: If activities are too long the students lose concentration and their attention falters.
- Week 3: Confusing examples, or difficult or strange language inhibits collaborative activity.
- Week 3: This topic involves too much instruction.
- Week 4: The collaborative process has broken down - the students in Group 1 are in conflict with each other.

Month 2:
- Test pressures enhance individual work and diminish group work.
- Need to time limit continuous work otherwise group activity breaks down.
- The teacher exhibited a negative attitude towards some students over their behaviour.
- Week 5: The teacher stifled discussion (debate) on an issue.
• Weeks 7 and 8: The camps disrupted the development of our collaborative peer interactive classroom learning environment.

• Weeks 7 and 8: Camp weeks - the tenuous nature of our newly developed collaborative peer interactive classroom learning environment is evident as our collaborative processes falter.

• Weeks 7, 8 and 9: The students reduced endeavour indicates their 'tiredness' with the new school year and post-camp fatigue.

• In the second 'camp' week I taught the students the same material I had taught to the first 'camp' week students. Observations showed that I altered my approach to avoid potential learning difficulties and hence I stifled discussion and gave more direction when instructing. This process limited collaboration and the students did not score as well in their assessments. Not good collaborative practice. This situation could indicate a potential problem or limitation which would be of concern for teachers who always teach the same subject or course at the same level. In such cases stagnation, of the teacher, the students and the learning environment, is a very real possibility.

Month 3:

• Week 9: very anti-collaborative behaviour evident.

• Many 'negative' events arose this month - temporarily restructured 'Camp' groups, individually focused tests, lapses into non-collaborative practices.

• Week 9: The teacher delivered a 'pep' talk on working collaboratively.

• On occasions there is still too much teacher talk.

Months 4, 5 and 6:

• audio taping of one-on-one teacher student conversations is not an effective data source.

• As a teacher researcher, many limitations are overcome or diminished due to my professional experience.

• The MCI was useful in the early phase for setting up the environment but it is not as effective in monitoring the environment.

• A data category returned this month (Month 6) after not being evident in observations last month.

One 'limitation' of doing research such as this was that I had to continue with this approach regardless of the outcome. I lived and worked with the results of this research, however I did not perceive this as a limitation for I embarked on this study with the aim of changing my learning and teaching processes and that was what I had achieved.
Research Limitations

Research Limitations related to methodological limitations which occurred in this study. Many of these were highlighted in Chapter 3, when discussing the theory behind the methodological design for this study, and steps were taken to minimise the impact of these possible flaws prior to commencing the implementation. The following points re-visit some of those potential limitations to highlight my awareness and observance of them during the study. Many were overcome but most remained, to some degree, limitations of this study.

- I have not attempted to generalise my findings to my other classes or the wider education community. This was a limitation born of this type of classroom-based action research. This limitation was compensated by the fact that aspects of these findings could encourage other teachers to explore the ideas behind this implementation. This was indicative of the special role played by action research in the education research community.

- Despite having provided significant detail as to my beliefs and values which guided this research it was still a subjective work and this could be interpreted as a limitation.

- The extent to which the quantitative data influenced the qualitative observations could be perceived as a limitation in this study. The students and I would disagree, for we appreciated the motivation and guidance gained from the quantitative measures.

- The findings from this study are 'unique' and this is not disputed. However, the students and I believe that such uniqueness in no way lessens the significance of the findings nor the influence of the implementation on the participants.

- Limitations relating to reliability, validity, triangulation, generalisation and objectivity were described earlier in Chapter 3. In that discussion the degree to which this study could claim to have reliability and validity was established. The design and execution of this study supplied adequate triangulation, and generalisability was interpreted as meaning translatability and comparability for a study of this type. These were strong features of the methodology. The objectivity of this study was determined by how well it informed others of the processes and results so that they could empathise with and share in its outcomes through their own duplication of this implementation.

- The data reduction processes utilised in this study could be perceived as excessive, removing much of the rich realism of the raw data. I believe this limitation was contained through the use of evolving, yet functional data categories which successfully exposed many of the facets of our learning environment's development. The categories evolved over the duration of the
study and were long lasting, indicating how well they matched the nature of the environment being observed.

- Observing according to the data analysis categories in the latter stages of the study could have been a limitation of the study. That these categories were still yielding disconfirming evidence as the study progressed diminished the impact of this limitation. The richness of the observations increased up to the end of the semester and thus the categories (numerous in quantity) maintained their integrity and quality throughout the implementation.

A significant outcome of this study related to the identification and use of a dynamic, classwide overlapping (multiple) 'zones of proximal development' model. Multiple interactions, whether one was involved personally or not, certainly enriched our learning environment and yet we acknowledged, as Vygotsky did, that this model had an operational limitation. "In collaboration the child can always do more than he can independently though not infinitely more. What collaboration contributes to the child's performance is restricted to limits which are determined by the state of his development, his intellectual potential" (Vygotsky, 1987, p. 209). Once assistance was removed, the student's performance potential was reduced as he or she reverted back to working at their actual level of development. This was a known limitation of the model which we observed in this study.

Being situated in the classroom placed many natural constraints on aspects of this study, however it offered comparative significance for a wide range and large number of teachers inquiring into similar situations. Some researchers may have perceived this study as being narrow in scope, having poor reliability in terms of replicability, or having little significance. I did not see such perceptions as valid due to the nature of the focus for this research. We set out to monitor change. The change was to arise due to our implementation of a collaborative peer interactive classroom learning environment. We monitored this change utilising a quasi-ethnographic (qualitative and quantitative) approach. "Qualitative research occurs in natural settings and often is undertaken to record processes of change, so replication is only approximated, never achieved" (LeCompte and Preissle, 1993, p. 332).

Replication could be difficult, in the case of this study, but duplication – doing what I did in another situation – is possible. "Because human behaviour is never static, no study can be replicated exactly, regardless of the methods and designs employed" (LeCompte and Preissle-Goetz, 1982, p. 35). As this study was an intervention applied to a whole class, we had no way of knowing or assessing progress for an intervention versus non-intervention (experimental research) situation. This was not
a limitation for this study: it was the reality for this type of classroom-based research. "Although research results generated by ethnographers whose positions were limited in scope may be narrowly applicable, they are nonetheless legitimate" (LeCompte and Preissle, 1993, p. 334). The final validation for this study was in my continued use of such learning environments.

**IMPLICATIONS AND RECOMMENDATIONS**

This section outlines the key implications from this study and notes some recommendations for teachers and researchers interested in building on the study's findings. Each of the major referents for this study, collaborative learning, constructivism, learning environment measures and Vygotskian pedagogy, are examined along with some of the more useful aspects of the methodology.

**Collaborative learning environments**

Implications and recommendations relating to collaborative learning environments are described in the following points:

- **Assessment** - collaborative learning environments should use group-worked tests / projects / investigations as much as possible. That is, the assessment should reflect the environment. The use of a group-worked test further illustrates how this study "contributes to the growing base of scientific knowledge about mathematics teaching and learning and complements the efforts of mathematics educators to reform current assessment practices" (Research Advisory Committee of the NCTM, 1988, p. 343).

- Collaborative learning environments could develop their classroom norms based on the work cycle model discovered in this study. The work cycle was attention to instruction, questions for clarity, discussion within groups, individual working and more group discussion and checking. The model noted the need for tasks to be broken into manageable activities of suitable duration - around 20 to 30 minutes. Thus lessons should contain several different sections. This issue also raises interesting questions about the length of tests - something to consider for the future. The model also noted the 'Noise' cycle evident in classroom activity: quiet initial engagement and increasing noise as a task progresses, with events such as the end of discussion or questioning leading to decreased noise levels. When explanations are explicated, the noise returns and the cycle resumes. A teacher's awareness of these traits would enhance the development of a collaborative learning environment.
• Teachers working in collaborative learning classrooms need to be aware of the various roles of noise within the environment. They also need to raise the students' awareness as to how they can learn through the passive process of actively listening, an essential skill for collaborative work. The teacher must also be prepared to allow multi-voiced discussions to emerge in the environment. These processes reflect a social skill utilised by the students outside of the classroom. This needs to be monitored to ensure that adequate information is arising from the discourse.

• The environment that resulted from this implementation provided "opportunity for both individual and collaborative learning" (CC, 1998, p. 36). Teachers implementing collaborative learning in their class should endeavour to have the group model the individual. The resulting behaviours and norms are comfortable for the students and lessen the impact when they move from collaborative to non-collaborative environments and visa versa. The Johnson's (1990, p. 30) concepts of "individual accountability" and "positive interdependence" are much more easily realised in an environment where groups have evolved to model individuals.

• Teachers in collaborative learning environments must encourage questions and answers at all times for these are the basis of much of the class discourse. The teacher should endeavour to accept all student input and utilise it in some positive constructive way (easier said than done!) Questioning enriches the quality of discussions and explanations which in turn enhances learning.

• Current trends towards outcomes-based, student-centred education endorse collaborative learning environments because they provide "a cooperative and non-threatening atmosphere and a supportive environment for learning" (CC, 1997, p. 202), in which students can work "collaboratively and with teacher support" (CC, 1998, p. 193)

• Collaborative group work needs to be just that. If it is compulsory or forced it will not work. It is not achieved just by setting up a group-structured physical environment. I believe the students need flexible training in the techniques of collaboration at an early stage. "Fostering processes which enhance learning involves teaching students to work with peers" (CC, 1997, p. 202). Thus, for high school, (Years 8 to 12), collaborative processes should flow on in Year 8 from the students' primary (elementary) school experiences. As most students
exit primary school oriented towards group work, then its ongoing use should be straightforward to maintain. In future years the process should then be easy to retain and develop.

- A significant implication arising from this study relates to the teacher. I changed! I will keep using this type of learning and teaching environment, for this study has proven to me the value of the paradigms which informed and guided this implementation.

- This study also offers guidance to parents and students. Frequently children working at home on the school tasks ask their parents for assistance, to explain difficult concepts to them. The content or methodologies involved are often lost to a distant past, or completely foreign to the parents. As a teacher, I am frequently asked how should the parents deal with this situation. My answer is based on the findings from this study and reflects the strong social relevance of the findings. The key is to make the student the teacher - a role they are quite familiar with if they are working in a collaborative peer interactive classroom learning environment. If the child can tell their parents about the problem / work / mathematics and explain it, if they can teach it to their parents, then they must know what they are talking about. I encourage the parents to encourage their children to 'teach' them. It does not matter if the parents do not understand the content initially, as long as what their child explains makes sense to them. This illustrates that the child has a basic grasp of the ideas to build on and then, on the basis of what they have seen, the parent in return can enthuse the child with the confidence they need to tackle further problems. If the child cannot explain the mathematics logically or clearly, then this indicates that they need more help from other 'experts', such as the classroom teacher or their peers, to identify and clarify the difficulties and remedy them.

Constructivism
Implications and recommendations relating to constructivism are described in the following points:

- As a result of this implementation I now perceive constructivism as a useful referent for my learning and teaching practice and for helping to establish the classroom learning environment for my students. This study has clarified for me the role that constructivism can play in learning and teaching, and thus it can assist others in the same way as they probe the value of this paradigm in relation to their own endeavours.
• The socio-cultural constructivist perspective best informs and guides the processes at work within a collaborative peer interactive classroom learning environment, for this perspective acknowledges the roles of each individual and the collective and enhances mediation between them. Teachers can enrich their knowledge of how such environments function through consideration of this facet of constructivism.

• The other facet of constructivism which I found most useful was the emphasis on prior experience and knowledge. Most teachers and researchers now acknowledge that learning relies on the construction of new concepts being founded on established knowledge. "Learning is built on existing knowledge" (CC, 1997, p. 199). We realise the importance of determining what is known in order to enhance the student's potential to understand and learn what is to be known. Teachers and researchers can utilise these processes to understand how the collective develops its taken-as-shared reality. This then becomes the foundation upon which all the students, individually and collectively, can build their knowledge. Thus through collaboration, the potential outcomes offered by a constructivist perspective are enhanced. This facet of constructivism is important to the foundation of the new Curriculum Framework currently being implemented in Western Australian schools.

    The students' existing knowledge should be recognised and used as the starting point for further learning. It should be extended to include the complementary knowledge, with the new knowledge being linked to, building on and challenging the students' existing ideas and strategies, so that over time they develop mathematical understandings which are both commonly accepted and over which they feel some ownership (CC, 1998, p. 208).

• Constructivism, especially the facet involving prior knowledge, must be modified when the Vygotskian notion of the 'zone of proximal (potential) development' is utilised in a learning teaching model. The Vygotskian perspective requires that we examine ways of learning and teaching which reflect a model based on learning potential and not only previously acquired skills.

**Learning environment measures**

When teachers or researchers set themselves the task of improving a learning environment, measures such as the MCI, the CLES or similar are well worth considering. The CLES suits those endeavouring to achieve a more constructivist oriented environment, however the MCI is very useful for more general changes. In
this study the MCI was especially valuable in the early stages of the implementation as the learning environment was being established. The MCI is also useful as a device to monitor the state of a learning environment over time. This study utilised the MCI over an extended period of time. In doing so we found that the "W" shape dominated the class data graph. Future studies could determine if the "W" shape is indicative of collaborative peer interactive classroom learning environments.

**Vygotsky**

Implications and recommendations relating to Vygotskian pedagogy are described in the following points:

- One of the aims of this study was to establish and validate the practical classroom application of Vygotskian pedagogic theory. This was certainly achieved and hence provided valuable insight, for teachers and researchers alike, as to the role played by Vygotsky's ideas in the modern classroom.

- Vygotsky promotes learning through social interaction and this was the nature of the environment we established in our class. Socialisation puts the peer interaction into the collaborative classroom learning environment. Thus it can be seen that Vygotsky's ideas can be utilised to construct and support the use of collaborative peer interactive classroom learning environments.

- Vygotsky describes learning as a process of concept development engaging the student's 'everyday' concepts and their 'scientific' concepts in continual interaction as new knowledge builds on and transforms old knowledge. This process links with the constructivist notion of the role of prior experience in learning. In this study we were able to extend earlier interpretations of these developmental processes and describe them as movement from joint regulation to self regulation. This study observed all of these processes in action illustrating how, by adopting a Vygotskian perspective, teachers and researchers can enhance their knowledge of learning processes in classrooms.

- Vygotsky's notion of the 'zone of proximal development', as developed in this study, provides teachers and researchers with a very valuable and powerful tool through which they can model learning and development. By recognising the dynamic nature of each individual's 'zone of proximal development', we are more able to acknowledge the developmental processes of learning involving 'scientific' and 'everyday' concepts as they emerge and evolve in the student's proximal 'zone'.
• By placing individuals into collaborative groups we extend the 'zone of proximal development' model to one involving dynamic overlapping (multiple) 'zones of proximal development'. These collective 'zones' have far greater developmental potential than any one isolated individual 'zone'. This new model serves as an excellent construct for teachers and researchers wanting to establish, develop or enhance collaborative group work in the classroom. It is through an understanding of how the dynamic overlapping (multiple) 'zones of proximal development' function that teachers and researchers can extend the role, value and viability of collaborative learning in the future.

• Viewing the set of groups as a class results in the formation of a classwide dynamic 'zone of proximal development'. This is a model which allows the students to take responsibility for their learning, something which is paramount in the outcomes-based classrooms now emerging as the newest trend in educational thinking. Vygotsky's notion of the 'zone of proximal development' has provided this study with the basis for developing a model of a functional and effective collaborative peer interactive classroom learning environment - a model which sees individuals and their dynamic 'zones of proximal development' situated in groups that collectively have dynamic overlapping (multiple) 'zones of proximal development' and constituting a class which has a classwide dynamic 'zone of proximal development'. By embracing the individual, group and classwide models of the 'zone of proximal development', and recognising it as a dynamic entity, teachers and researchers will be able to further develop collaborative learning practices in all areas of education.

Methodology
Implications and recommendations relating to the methodology utilised for this study are described in the following points:

• This study added to the collection of teacher researcher works. That teachers can do this type of research is established by this study and it highlights the validity of the calls for more of its kind (Davis et al., 1990). Teachers, or perhaps teachers and researchers working together, need to examine educational processes as well as learning and teaching processes utilising a methodology similar to the one presented in this study.

• Change is perpetual in education, and changes need to be monitored to ensure that the direction in which education is evolving remains focused on providing the best possible outcomes for the students. This study provides teachers with
many methodological tools through which they can monitor change and ensure its suitability for their situation. Thus, on a smaller scale than this study, teachers can engage in action research to reflect on their practice and monitor the learning and teaching environment.

- Some of the tools from this study which teachers might utilise include:
  - a small scale action research project focusing on an issue of interest
  - fieldnotes of classroom processes - useful for a fixed or limited time period
  - audio recordings of the class - to explore classroom or student interactions over a short period of time.
  - video recordings of the class - to review a single lesson or activity in greater detail.
  - independent observations of the class - for an alternative viewpoint or interpretation of the teacher's and the students' classroom practices.
  - learning environment measures such as the MCI or CLES - to focus on learning environment enhancement.

- future research, along a similar design, may be further enhanced by considering the following ideas:
  - teachers carrying out such research should have one less class, the equivalent of a 20% reduction in workload, to be able to facilitate the methodological requirements of such research.
  - utilising a computer software system to manage the narrative or qualitative data would allow the research to include more transcripts from audio and videotape sources to supplement the data analysis.
  - future research could adopt the Vygotskian model of a 'teaching experiment', also known as a formative experiment, to focus on understanding the transformation towards a particular outcome. This may be especially meritorious given the new trend towards outcomes-based education processes (CC, 1998).
  - a future study may benefit from focusing on the changes related to only three groups, or ten to twelve students, rather than the six groups, twenty one students, observed in this study.
Chapter Summary
This chapter has summarised the findings from the study and drawn conclusions relating to the study's research questions. It has reviewed the limitations that arose throughout the design and implementation stages of the study, has made some recommendations to teachers and researchers regarding the use of collaborative peer interactive classroom learning environments and has highlighted implications for those pursuing similar work through follow-up and duplication studies.

This study has shown how a collaborative peer interactive classroom learning environment can be enriched and enhanced through the adoption of Vygotskian and constructivist perspectives. The students and I will now continue with the business of running our collaborative peer interactive classroom learning environment for the remainder of this implementation, semester 2 of the school year. For Term 3 we shall form heterogeneous groups based on mathematics ability, and for Term 4 the students may self-select 'friendship' groups. We are pleased with the success of our implementation and we value the benefits that collaboration has brought to our learning and teaching environment. We will now promote this model to our peers and colleagues as we face a future of continuous learning.


Education Department of Western Australia. (1984). *Small group work in the classroom* (revised ed.). Perth, Western Australia: Language and Learning Project, Curriculum Branch, Education Department of Western Australia.

Education Department of Western Australia. (1987). *The unit curriculum - Mathematics* (revised ed.). Perth, Western Australia: Curriculum Branch, Education Department of Western Australia.


Montessori, M. (1912). The Montessori method. NY Stokes


APPENDICES
### APPENDIX 1

#### Table 22
The teacher’s (my) timetable.

<table>
<thead>
<tr>
<th>IRELAND</th>
<th>TIMETABLE</th>
<th>MATHEMATICS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Day 1</td>
<td>Day 2</td>
</tr>
<tr>
<td>Period 1</td>
<td>10M6/7</td>
<td><strong>8M5</strong></td>
</tr>
<tr>
<td>8:30am - 9:15am</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Period 2</td>
<td>12DM3</td>
<td>9M1</td>
</tr>
<tr>
<td>9:20am - 10:05am</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tutorial</td>
<td>Chapel</td>
<td>Tutorial</td>
</tr>
<tr>
<td>10:10am - 10:30am</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recess</td>
<td>10:30am - 10:50am</td>
<td></td>
</tr>
<tr>
<td>Period 3</td>
<td>11IC4</td>
<td>11IC4</td>
</tr>
<tr>
<td>10:50am - 11:35am</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Period 4</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>11:40am - 12:25pm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Period 5</td>
<td><strong>8M5</strong></td>
<td>Assembly</td>
</tr>
<tr>
<td>12:30pm - 1:15pm</td>
<td></td>
<td>Department</td>
</tr>
<tr>
<td>Lunch</td>
<td>1:15pm - 1:55pm</td>
<td></td>
</tr>
<tr>
<td>Period 6</td>
<td>9M1</td>
<td>10M6/7</td>
</tr>
<tr>
<td>1:55pm - 2:40pm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Period 7</td>
<td>---</td>
<td>12DM3</td>
</tr>
<tr>
<td>2:45pm - 3:30pm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In Table 1 above, **8M5** indicates the class engaged in this study, Year 8 Mathematics Group 5. **9M1** indicates my Year 9 Group 1 class (top academic stream). **10M6/7** indicates my Year 10 Group 6/7 combined class, with two teachers, (bottom academic stream). **11IC4** indicates my Year 11 Introductory Calculus class (Group 4). **12DM3** indicates my Year 12 (University entrance level) Discrete Mathematics class (Group 3). These were the classes I taught during the year I undertook this study.
## APPENDIX 1

### Table 23

The Year 8 mathematics course.

<table>
<thead>
<tr>
<th>Term 1</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Shapes and Solids</td>
<td>(6)</td>
<td>G</td>
</tr>
<tr>
<td>Rule of Order of Operations</td>
<td>(5)</td>
<td>Ar</td>
</tr>
<tr>
<td>The Integers</td>
<td>(9)</td>
<td>Ar</td>
</tr>
<tr>
<td>Relationships and Functions</td>
<td>(14)</td>
<td>Alg</td>
</tr>
<tr>
<td>Measurement</td>
<td>(8)</td>
<td>Ar</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Term 2</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Angles</td>
<td>(5)</td>
<td>Ar</td>
</tr>
<tr>
<td>Expressions and Equations</td>
<td>(12)</td>
<td>Alg</td>
</tr>
<tr>
<td>Coordinates</td>
<td>(10)</td>
<td>G/Alg</td>
</tr>
<tr>
<td>Decimals</td>
<td>(7)</td>
<td>Ar</td>
</tr>
<tr>
<td>Area</td>
<td>(7)</td>
<td>Ar</td>
</tr>
<tr>
<td>Chance Processes</td>
<td>(9)</td>
<td>St</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Term 3</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Primes, Factors and Multiples</td>
<td>(10)</td>
<td>Ar</td>
</tr>
<tr>
<td>Rates and Ratio</td>
<td>(12)</td>
<td>Ar</td>
</tr>
<tr>
<td>Similarity</td>
<td>(9)</td>
<td>G</td>
</tr>
<tr>
<td>Volume and Capacity</td>
<td>(9)</td>
<td>Ar</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Term 4</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Symmetry</td>
<td>(8)</td>
<td>G</td>
</tr>
<tr>
<td>Statistics</td>
<td>(10)</td>
<td>St</td>
</tr>
</tbody>
</table>

**NOTE:** Alg, Ar, G and St indicate the mathematics strand of each topic namely Algebra, Arithmetic, Geometry and Statistics respectively. The number in brackets indicates the approximate number of lessons allocated to each topic.
APPENDIX 1

Figure 20

Year 8 General Mathematics Notes

Suggestions and Guidelines

1. Students should be encouraged to operate a dual file system:
   a) An A-Z file at home for storing completed topics
   b) A half-file for current work, divided amongst the other subjects.

2. All students must have the following equipment: Pens; pencils; eraser; ruler or Math-O-Matt or Math-Aid; Proliner; and a Scientific Calculator, preferably a Canon F800.

3. 5 minutes in most lessons should be devoted to oral or written mental and numeracy drill. Suggest 5 to 10 questions related to current work or review of previous work. Students should keep their own records and the results could be used as part of non-test-based assessment.

4. For each topic students will be either:
   a) Required to write a summary report about each topic outlining:
      What we did
      How we did it
      What I learn from/about this topic.
   OR
   b) Required to complete some equivalent assessment recorded by the teacher.

5. Class tests will be 40 minutes. End of term tests will be 40 minutes. Other assessment will be the summary/topic mark which includes mental, homework, quizzes, and so on.

6. This year’s Year 8 Parents’ Mathematics Night will be during Week 3. For the evening it is suggested that there be an introductory family-based task (e.g. Pentominoes) for the first 15 minutes to allow for late arrivals and get those attending in the mood for maths.

7. All students will undertake either a Math-O-Quest Project in Terms 2/3 or some equivalent piece of extended work such as an investigation or project which is school-based.
APPENDIX 1

Figure 21

Learning Mathematics

* The underlying philosophy of the present approach is:

LET THE LEARNER LEARN BEFORE THE TEACHER TEACHES

* The emphasis is on non-routine problem-solving, using group discussion.
* There is a corresponding de-emphasis on rote learning and repetitive algorithms.
* Students communicate with their peers in both oral and written form.
* The computer should be an integral part of the problem-solving process.
* The investigation aspect and the report writing are central to this approach.

* INDIVIDUAL WORK
  WHAT I FOUND OUT ON MY OWN.

* GROUP WORK
  Extension - what our group found out

* CLASS SUMMARY
  Conclusions and summary of class discussion.
APPENDIX 1

Table 24
Year 8 Assessment.

<table>
<thead>
<tr>
<th>Term 1</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid-term test</td>
<td>5%</td>
</tr>
<tr>
<td>End of term test</td>
<td>8%</td>
</tr>
<tr>
<td>Summary / Topics</td>
<td>10%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Term 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid-term test</td>
<td>5%</td>
</tr>
<tr>
<td>End of term test</td>
<td>8%</td>
</tr>
<tr>
<td>Summary / Topics</td>
<td>10%</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Term 3</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid-term test</td>
<td>5%</td>
</tr>
<tr>
<td>End of term test</td>
<td>8%</td>
</tr>
<tr>
<td>Summary / Topics</td>
<td>5%</td>
</tr>
<tr>
<td>Project / Investigation</td>
<td>5%</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Term 4</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Mid-term test</td>
<td>5%</td>
</tr>
<tr>
<td>End of term test</td>
<td>6%</td>
</tr>
<tr>
<td>Exam</td>
<td>20%</td>
</tr>
</tbody>
</table>

The Summary/Topics component includes teacher marks for mental, homework, and so on.
Year 8 Mathematics with Mr. Ireland

Mathematics is a subject both to learn and enjoy and everybody should have a positive experience of mathematics. Your mathematical experiences began at home, continued through your social life and also in school. Learning mathematics is an active social process in which you need to discuss, listen, negotiate, compare meanings and theories, make conjectures, offer explanations and justifications in oral, written work and when reading so you can make connections among verbal, symbolic pictorial, physical, graphic and mental representations of mathematical ideas. Now that's saying something!

Mathematics should not be viewed as a 'content experts' subject but as a useful tool to help you work through all sorts of activities. You will find that there is quite a difference in what can be achieved with support compared to without support and so to facilitate your personal learning we need to maintain that primary school approach: 'we are all in this together'.

Therefore in our mathematics class this year we will be working in groups. Some of you will have had experience of this in primary school and it does work very well in high school too! By working in groups we hope to create a less threatening environment through the sharing of problems. The group can provide help, guidance and answers for those who need explanations and we can all learn more through discourse, collaboration and negotiation. In such an environment we can freely explore mathematical ideas, ask questions, discuss concepts, make mistakes and hopefully encourage each other to perform better and learn more.

Group work means negotiating your explanations and solutions into a group consensus. Your group will have to make decisions and evaluate importance and progress. This will make you more responsible for your own thinking and learning. Working in a group fosters peer teaching which allows the students to explain things, sometimes better than the teacher, by using more appropriate language and when explaining something to a peer we often see things more clearly and can spot inconsistencies in our own thoughts which allows more readily for the restructuring of misconceptions, where they exist. Talking can show you that there is often more than one way to deal with a situation while listening to other students' ideas and encouraging them to listen to you and each other develops mutual respect. We must value and respect what each other knows because doing so enhances everyone's self esteem and worth. In this mathematics class you will be challenged to go beyond your current thinking as we continually increase your capacities.
APPENDIX 1

Figure 23

How does it work?

The following ideas will need to be worked out as your group develops. Give it time!

You must be willing and able to work collaboratively and value the contribution of others. This means sharing your thinking and strategies with others. Everyone must ensure that they themselves and the other students in their group master the material. Each person in the group must discuss the task with every other person in the group during the work period. Everyone must monitor each other and stay cohesive, that is don't let anyone 'drop out' and always work within your own group. Listen to and try to make sense of explanations given by others and feel free to indicate whether you agree with, disagree with, or simply don't understand their explanations. Remember to 'say what you mean and mean what you say'.

Anyone from the group can be asked to discuss the group's solution. You must believe or perceive that the activity or tasks which you are required to work on are of joint interest to you and your fellow group members. To help your group to develop into an effective team we will only be working on one topic at a time. Feel free to express concern to the teacher if you perceive that the group is failing to function effectively but remember that teacher assistance can only be obtained if all hands in the group go up. Ask the teacher questions as a last resort - ask your group members first.

The following example of a group design may be useful to you but remember to change the roles and responsibilities around quite regularly.

Leader (Actor) Takes a leading role and keeps everyone on task.
Timer (Director) Monitors group practices and keeps the group on time.
Reporter (Writer) Records the work to be handed in and presents the results.

Of course, everyone keeps a record of the work done for their own use.
Supplier (Producer) Secures and supplies all of the equipment needs such as worksheets, materials, and so on.
APPENDIX 1

Figure 23 (continued)

Remember;
(1) you 'sink or swim together',
(2) you must work to ensure that every group member learns,
(3) you must discuss the material being learned face to face.

Initially the teacher has selected the groups but once you have learned to work effectively in
groups we may adopt student selected groupings.

As your teacher I will value;
- students who cooperate to solve problems,
- meaningful activity over correct answers,
- persistence on a personally challenging problem rather than completing a large number of
  activities,
- groups which reach consensus as they work on the activities.

Your individual obligations include;
- figuring out solutions that are meaningful to you,
- explaining your solution methods to the group,
- trying to make sense of the other member's problem solving attempts,
- establishing the social skills to work collaboratively.
APPENDIX 1

Figure 24

How are you assessed and graded?

A. GROUP ASSESSMENT:

Groups will be rewarded for doing well as a group. The group’s success will also depend on the individual learning of each group member.

For example;

(i) when a group member presents a correct solution, the group gets extra marks (=10%) added to the assessment for that piece of work,

(ii) each group member gets the same mark for the written work submitted by the group,

(iii) every time the group’s average improves each member of the group gets extra marks (=10%) added to their results,

(iv) when an individual’s average improves, each member of the group gets extra marks (=10%) added to their results (see below).

The group will also be assessed by teacher observation.

B. INDIVIDUAL ASSESSMENT:

Individual performances will be required on;

(i) mid-term, end of term and end of semester tests and exams,

(ii) selected homework pieces,

(iii) other non-test items.

Individuals will also be assessed by teacher observation when doing individual and group work.
APPENDIX 1

Figure 25

Types of assessment:

1. Tests and Exams - one mid-term test and one end of term or semester test or exam per term.
2. One major project during terms two and three (Math-O-Quest).
3. Non-test assessment via your 'portfolio'.

PORTFOLIOS:
Your understanding of mathematics concepts can be enhanced through an exposure to a
variety of representations for example writing, calculating, modelling, drawing, talking,
listening, and so on.
You will collect together selected pieces of work throughout each term and these will
represent your non-test assessment. Some items will be individual work, others will be from
your group. Some items will be teacher selected, others you may choose to include. Items
will include: topic summaries, quizzes, homework, mental, special problems and selected
writings.

WHY WRITING?
By using writing to learn in mathematics you can focus your thinking towards a better
understanding of the subject matter. For example, writing at the beginning of a lesson helps
you focus on the tasks to be done in class. Through a journal you can describe your
mathematical experiences, reflect on your thinking and clarify your feelings about
mathematics. You may be asked to describe your mathematical knowledge in a narrative
form or with a summary you could integrate this mathematical knowledge into a connected
collection of discrete items or just tell someone else, in a dialogue, how you are involved in
creating and shaping your mathematical knowledge. Writing about how you approach
problems not only helps your understanding but also makes your thinking clearer and
sharper.
APPENDIX 1

Figure 26

Perceptions.

In mathematics the way students think and learn is more important than the teaching strategy used.
Your attitude to mathematics will greatly affect your success and enjoyment so we will constantly reflect on how we think we are doing.
Once every four weeks or so, we will measure and monitor your perceptions of the actual classroom environment and what you would prefer. This will take the form of a brief questionnaire which you can add to your portfolio. Less frequently, once a school term, we will complete a similar but bigger questionnaire. These are not marked for your grades but they are used to determine how well we, as a class, are functioning and how best we can improve things.
In addition to these questionnaires some teacher observations and tape recordings of the class, of groups working and of individuals working will add to our ideas of how this class learns best.
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<thead>
<tr>
<th>Student Number</th>
<th>Previous school location</th>
<th>Maths ability</th>
<th>Writing ability</th>
<th>Reading ability</th>
<th>Group vs Individual</th>
<th>Mature?</th>
<th>Overall ability</th>
<th>Comments</th>
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<td>lc</td>
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APPENDIX 1

Table 26
Coded student data.

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<th>Writing ability</th>
<th>Reading ability</th>
<th>Group vs indiv</th>
<th>Mature?</th>
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APPENDIX 1

Table 27
Ranked student data.

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APPENDIX 2

OBSERVATIONAL DATA FOR MONTH 1

This appendix contains the data collected during the first month of the implementation and is constituted of observations, reports and results.

The text of the collected data, raw data or synthesised data, is shown like this, in Helvetica font.

This data was synthesised each week into weekly reports and these were collated into the monthly reports presented in this appendix. The collations focused on the key areas which became apparent during Month 1 of the study. The key areas were: the student document (first principles); marks and assessments; group work ethic / process; our environment; support and criticism; listening skills; questioning skills; teacher comments and observations; tape / video recorder; specific events. The key focus area group work ethic / process was further analysed under the following additional criteria: group work process; discussion and explanation; background; tasks; noise; behaviour; help; homework; observations.

2.1  MONTHLY REVIEW #1:  February - Weeks 1 to 4 (inc)

The next section presents the observational data collected during the first four weeks of the implementation, Month 1. The data is delineated into the categories described in Table 1 in Chapter 3. Within each category the data is presented in chronological order from week 1 to week 4. The category Group Work ethic / process is further divided into additional criteria as discussed earlier. Following the observational data, the data arising from the specific event for Month 1, an MCI classroom environment survey is presented.

2.1.1  The student document / re-focus on first principles.

Week 1:  
The student document was addressed on two occasions. This requires further attention, in conjunction with the student data collected so far.
2.1.2 Marks for groups.

Week 1:
Allocating group scores and bonus incentive marks is proving a difficult process. The effective use of group assessment ideas and instruments needs to be developed. Assessment instruments, guidelines and procedures are complex and the students do not have a clear understanding of them. This usually comes with time.

Week 2:
Marking must involve the collection of every student's work for a personal score but with the group's choice indicated. Just collecting one piece allows other students to not complete the work.
Photocopies are made of student scripts when group reports are submitted. The marks are discussed with the students when they receive their scripts back.

Week 3:
On some of the MCI questions the students were not certain enough to be able to answer Yes or No. This is acceptable in terms of scoring their responses.

Week 4:
The value of keeping a record of results was found when such result reflected a better performance than was the case after an earlier class survey of the same quiz. Teacher recording of results has improved.

2.1.3 Group Work ethic / process.

Week 1:
Groups have evolved comparable work regimes; namely - noisy organisation and distribution of tasks, relatively quiet individual work on tasks, and noisy sharing and discussion of solutions or problems encountered.
As the environment becomes more comfortable for the students they open up more with the volunteering of information and better questioning and querying of each others and the teacher's work.
Self starting, by the students, still has not reached acceptable levels.
Most groups have 'controllers' or leaders and some have more than one and this may lead to conflict. Usually, someone is trying to dominate and impose their ideas. While this may have worked early on it is more difficult to achieve now that everyone is more critical and questions such assertions more.

Week 2:
Student interaction through the use of facilities such as the blackboard is to be encouraged. Having to demonstrate a concept to others on the board makes the students clarify their own ideas first and it enhances class attention and collaboration.
Debate is sometimes founded on misunderstandings and if it goes on too long it degenerates into negative arguments.

At this stage the teacher is directing task discussion but the students do occasionally take over this role.

Students comfort with teacher led work means that when this occurs it does not affect their collaborative progress or development. The students are interacting more when this type of work occurs than they did at first and they discuss each others ideas as much as they discuss those of the teacher.

Follow up activities see a more rapid progression by the students into group work. The personal discovery phase of independent work is by-passed.

Having something to strive for or better seems quite motivational.

There is some reluctance within groups to share work done individually.

Just because the group has done an activity is no excuse for individuals to not have a personal copy of the work.

**Week 3:**

Most of the students have not made a commitment to learning. They exhibit little recall or retention of recently covered facts. This may be addressed by the pressure of a test or may need further attention subsequently.

Students seem very keen to use the group work technique for all aspects of their classwork.

Two students missed a lesson and returned to class but had no questions. The groups must have briefed them adequately. In fact when questioned about this both claimed the group did nothing, they just caught up the work themselves.

Time limits seem to enhance group activity.

The quantity of work completed in a session varies widely.

Groups as a whole do not seem to be self starting.

Group exercises lead to collectively identical solutions but errors can lead to recriminations within the group.

**Week 4:**

Boredom within a topic can lead to the degeneration of the groups functioning.

Each group should give answers to one of its members when they are asked questions by the teacher.

The level of collaboration on tasks has increased from the reluctant beginnings, through the teacher prompt and student respond stage to the almost self starting stage. Groups vary as to how far they have progressed in this development.

The students have evolved from passive uncertain beginnings to a much more assertive collection of 'individuals' by months end.

Volunteer reporting to the class has progressed significantly from the reluctant few to the overwhelming majority. This may be seen as a good sign of the developing environment.
2.1.4 (a) Discussion / Explanation

Week 2:
Class room discussions can be 'offensive' or 'defensive'. Listeners benefit greatly from such a debate. Competitive vocalisation spurs activity and gives the environment a lift. There is evidence of the students taking the initiative in directing the class discussion as they analyse solutions to problems. The students can lead the class and the teacher through various points of discussion with a series of questions. 'Normal' behaviour is evident when taking notes. These are recorded quietly then some within group discussion takes place as they try to absorb the facts and finally a class discussion arises as clarification and explanation is sought. The students are fairly polite in discussion and take turns to talk but at times the 'all talk at once' mode occurs and seems just as effective. Individual work is difficult to instigate as some level of chatter always occurs within the groups. The language of the student needs to be emphasised while the mathematical language needs to be learnt. Student input enhances the value of facts and places some degree of ownership with the students. Alternative methods and re-explanation by the teacher leads to quite a bit of discussion among the students who are seeking to understand a concept. The use of the word 'Why?' often elicits student input and comment and therefore values student opinion and knowledge. Social banter which surfaces during discussions brings out different views of the students for all to see.

Week 3:
Asking students to explain their answers often leads to clarification of the students' misconceptions. This shows the value of verbalising solutions. The PROXIMAL 'ZONE' is open and peer teaching is in full swing when the students lead a class discussion of results and resolve each others mistakes. Group consensus sometimes precludes the need for or the desire for class consensus. Group discussion of work now involves a hive of activity. Progress in this regard has improved with students referring to each other when they need to know something.
2.1.5 (b) Tasks

**Week 2:**
The students focus on the present activity and do not seem to be able to do so while reflecting on the previous activity.
The students are more effective investigators when the rules are clear and they are given the independence to get on with the task in their groups rather than as a teacher led class.

**Week 3:**
Drill work for more than 15 minutes leads some to disruptive behaviour. A variety of tasks on offer seemed to work better at maintaining students on task.

**Week 4:**
Practical examples sometimes cloud or confuse the concept being addressed.
Non-mathematical language sometimes confuses the mathematical ideas for many students.
Effective group work breaks down when groups have to have several different tasks going on at one time.

2.1.6 (c) Help

**Week 2:**
The groups have not yet developed sensitivity to members needs. They must listen more and be more responsible for each other.
Members must be more assertive within their groups when they need help.

**Week 3:**
The students saw the personal value of the group when they responded that their quiz results had been improved through group interaction. No one said the group had detracted from their quiz results.

2.1.7 (d) Month review - Group Work ethic / process

Task - 'joining squares'
The teacher emphasised the rules and led the development of the initial ideas. The students did the drawings but worked fairly independently. The students initially said an answer but they had not drawn all the possibilities. Eventually they realised that they had to work within the guidelines given and as they returned to consideration of the task the teacher withdrew his guidance and the students became more effective explorers and developed their solutions more in their groups and less independently.
The teacher collected the class consensus on the number of solutions. Again the students clarified the rules verbally and the teacher presented their ideas as an alternative to those he initially outlined. The problem was then extended. The students began work on this initially independently however, as their personal ideas
dried up, the went to their group seeking clarification and confirmation of the ideas they had developed. The teacher acknowledged a ‘bid’ of 4 as a solution and then the environment relaxed as others opened up and offered bids of their own. Quite a degree of banter developed including intra- and inter-group questioning and asserting. The teacher and the students were all involved in checking their own or their group’s results to develop a full set of solutions. This entire process enhanced and increased the discussion / debate level in the class.

2.1.8 The environment - group size and effect.

Week 1:
Indications such as body language, discourse, general demeanour and so on, suggest a fairly relaxed environment exists, although an early uneasiness with group work was evident in some students’ body language.
Three person groups do not seem to be functioning as well as four person groups.
Suggest that at the next arrangement, if still 21 students, we go for a $4 \times 4 + 5 \times 1 = 21$ students in 5 groups.
Some inter-group communication has occurred and while not ‘harmful’ the teacher must try to keep this in check.
The pace of the class, through the required work, is determined in this class as in others; namely by the level which the groups or students are ‘on task’.

Week 2:
The students do not yet know enough about each other to value the similarities or differences in their widely varying backgrounds.
The purpose of an activity can be defeated by having the solutions in the back of the book but more significantly this also robs the students of the understanding they seek.
The early use of manipulatives resulted in a lot of individual work. As the students became more sure of themselves they opened up a little while using manipulatives.
Computer demonstration of concepts does not attract students unless they are empowered to use the facility themselves.
The vocalisation of solutions eases tensions or pressures within the classroom environment and frees up discussion.

Week 3:
Before the next MCI and before the groups are restructured the students should mix a bit more to learn more about each other.
Blackboarded instructions facilitate self starting.

Week 4:
Manipulatives require ‘play time’ as the students familiarise themselves with the equipment.
A personality clash had developed within a group and the teacher discussed this with the group member who hinted at the problem. It was agreed that the problem would need to be
resolved / addressed further but that it was the students' task to sort something out. They operate as many other groups do, namely they try things individually then they discuss their solutions but at the moment seem to be non-collaborative, non-communicative. After observing the three students for a time the teacher highlighted the need for the group to care for and help every member. They are a good group and if they are aware of the problem then maybe they can resolve it.

2.1.9  
Student support and criticism of each other and the teacher.

Week 1:  
Student support or criticism of student reports, ideas, and so on, and of the teacher teaching and of what is been learnt, has increased and is now common place. The teacher may still invite it but by now the students are quick to respond and participate.

Week 2:  
Some students feel it is necessary to publicly state their dislike of this subject. PROXIMAL ZONING in the form of the teacher leading the students in an analysis of what others are saying develops the students' skills in these areas.
Students are no longer reluctant to support each other or question each others ideas and this leads to building onto the ideas of others through class discussion.

Week 4:  
The students prefer to focus on fellow students, drawing solutions on the board, rather than on the teacher giving answers to other questions.
Students can demonstrate ideas visually and physically to the class.
A 'third party' (another student) can be engaged to resolve a conflict of answers between two students.
A very good level of student discussion leads to the exposure of quite a lot of student uncertainties on a topic.
The students are not accountable and may not finish of exercises.
The teacher asked the groups to be sure everyone has all the answers from an activity which results in considerable discussion as students share the solutions.

2.1.10  
Student listening skills.

Week 1:  
Student listening skills have improved but are generally still quite weak. The teacher is still required to remind them of the need to listen for comprehension, to inquire more.

Week 2:  
The students do not act on 'suggestions' but prefer 'directions'.

Week 4:  
Reading can be the emphasis of an activity.
2.1.11 Student questioning skills.

**Week 1:**
The students rarely question the group and are reluctant to make group consensus decisions on the problems or questions that any individual member may have. Instead, the focus is still on the teacher as a question and answer source.

**Week 2:**
The students start questioning the teacher once their confidence has developed and the 'teacher as expert' factor has been down played.

**Week 3:**
When reflecting questions the teacher is often able to utilise the students' present knowledge or understanding to extract a solution from.
When questions cannot be resolved within the group then they are put to the whole class rather than being answered by the teacher.
Students often refer to the teacher when first trying problems arising from a newly learned concept.

2.1.12 Teacher use of student features.

**Week 1:**
The teacher has made significant use of students' ideas / thoughts / questions / leads and so on in the environment. Some use of the student's backgrounds has been made but much still has to be done on this score.
Teacher follow up has improved, thanks to the tape and fieldnotes remincing about the unfinished business of the day.
If taking lots of fieldnotes some 'teacher disappearance' or time out may be required to reduce the 'being watched' atmosphere.
Teacher talk-fests have been reduced to a more acceptable level and are engaged with more purpose than was the case earlier.
The teacher has regressed into answering student questions rather than redirecting them to the student via another question or to the group for an answer.
The teacher has improved instruction giving techniques and less misinterpretation now occurs.
The teacher's listening to the students has improved although this will fluctuate depending on the lessons direction.

**Week 2:**
Teacher checking of individual work needs to increase.
The teacher's role includes the 'pepping-up' of the students when they feel low or tired.
Teacher instructions are not always clear. The teacher can ask the students to confirm instructions and thereby avoid multiple interpretations or misinterpretation.
Praise for success is valuable to student self esteem. Give it more freely.

To reduce the teacher as expert factor questions from students must be redirected whenever the others in the class are capable of answering it. Poorly thought out teacher instructions often lead to clarifying questions from the students.

If student opinions are important and valued then the teacher must follow up on student initiated thoughts and ideas.

**Week 3:**

Teacher lust or impatience can overrun student learning. A common practice is that teaching out paces learning.

The teacher can make their instructions clearer by making them shorter and leaving the organisational details to the groups.

As a model for effective group work the teacher emphasises each student's points, questioning and clarifying when needed.

If the teacher suggests uncertainty when giving solutions the students seem encouraged to question and debate those answers.

Teacher 'ignorance' or 'knowledge gap' is a powerful tool in getting students to explain things. This often makes the results clearer for other students as well because the language is more like their own.

Let everyone have their say - build up student confidence by using student answers and ideas - resort to step by step explanations when trying to make an issue clearer.

When the students cling to their past values and experiences the teacher must attempt to incorporate these as the new version of the concept is developed.

**Week 4:**

Teacher as expert seems to be a diminished factor as students now feel free to laugh at teacher mistakes however this freedom must be protected by the teacher as it is easily intimidated out of the students.

The teacher can move around the room and interact with groups discussing techniques and solutions, giving hints and suggestions far and wide when the students do activities. Very much a **PROXIMAL 'ZONE'** work environment.

The teacher positively guides students through tasks redirecting their thoughts on the activity. This works much better than just saying 'you're wrong, do it again'.

When the teacher asks a question which no one answers, not even the teacher, things stop. Eventually, a student idea is used by the teacher to build an answer from.

Giving an example of a new concept which is beyond the students' experience, beyond their **PROXIMAL** level means that most are unable to accept the concept.

In attempting to accommodate student ideas, which are poorly founded or are based on prior knowledge concepts only, an issue or new concept can become lost and unclear. Following student themes or ideas can also create confusion when dealing with a new concept beyond the immediate reach of some students.
The teacher must build from where the students are and not try to leap forward to a point beyond their PROXIMAL level. The students have wide ranging ability levels and some can do certain tasks while others cannot.

2.1.13 Tape Recorder.

Week 1:
The tape recorder is not an issue when out of contact but when it is close or nearby it can become an 'item'. It does not seem to have had any effect on the students as they work.

Week 2:
Interactive teaching and monitoring inhibits the taking of fieldnotes. The tape can sometimes fill in the gaps.

Week 4:
The tape recorder was a focus for students gathered around the teacher's desk.

2.2 My Class Inventory (MCI #1) - week 3

Teacher's comments on MCI #1: - this is a transcription.

OK, I'll now talk about the two sheets that I've given everybody.
[Students quietly talking amongst themselves as teacher begins address].
Those are the results of the last survey you did including the little graphs. You have a private graph, that's your personal graph somewhere there, you have the graphs of everyone else in your group, down the bottom you have your group's graph, the graph where we combined all the results so your fourth graph or your fifth graph is your whole group and everybody's got the same graph in the bottom right hand corner and that's your class graph, where everybody's results got put in together.

Comments on the overall class results for the MCI:

So looking at the last graph we can see, you'd all like more satisfaction but there is a high level of satisfaction anyway, but you'd like more satisfaction doing what you are doing.
You'd like less friction, you'd like a lot less competitiveness which possibly means that you like the idea of working together.
[students' collective response - "I like it". Teacher - "You like it?" Students - "Yeh!"]
[some other class chatter occurs about this point here].
The difficulty, this is the most interesting one, you're diamond says the difficulties are very low and your square is almost the same so you want it maybe a bit easier but not much.
Now that is an interesting result, you think this Mathematics you have been doing so far is not that difficult, or maybe just a bit, well it's almost perfect.
[Students' comment "Yeh, its OK", "maybe just a tinge easier"].
For the last category, cohesiveness, well were not doing as well as you want us to.

Now I will do the same graphs again for the ones you've done today and we'll see if its changed. As far as all of that is concerned none of that information counts for your marks and grades of course because that would devalue it. What you think about the class, how you think it's working, is the most important thing because now I know what I have to do.
Since this was done, I've had to try to increase the amount of enjoyment you get in the class, reduce the amount of conflict that's been going on, so I've tried to actually give you more information as to what the group work is about. I've had to try to make the work have less talk and more action and I've noticed in the last couple of weeks when you've been doing your group work you start out by asking me 'what do you mean', 'explain this', 'how do I do that', so you've been checking up on what to do to make sure you know its right, so we have improved there. In the beginning of the year I gave you homework and when you'd come back the next day, you didn't have a clue what I meant. You left class and you didn't have any idea at all on what to do. Now you question me saying 'what do you mean, explain it', so that's working better. Then you go quiet, the room goes really quiet and you get this period where you are all working individually on your activity, and that's good for your personal needs, then it starts to get a little bit noisier as a few people start to compare and chat, then it get noisier and noisier and if I ever say something like 'right, two minutes, make sure your groups got all the same answers' then the place goes crazy and gets really busy, [lots of amused giggles from the students here], heaps of noise, heaps of activity. You have developed into that pattern. Now maybe that's better because now you are a little more in your own mood, do your own work, that's the bit you need to share in groups. However I really value your opinion because as we see from these results, you are different from your group, your group is different from your class, and you are different from your class. So that's that set of results. What I would like to happen now is that I'd just like you to have a good look at your graphs so just explore each others graphs and have a chat amongst yourselves just for a couple of minutes. Explain to each other what you see in the results. Just spend a few moments comparing your results with each other.
APPENDIX 3

OBSERVATIONAL DATA FOR MONTH 2

This appendix contains the data collected during the second month of the implementation and is constituted of observations, reports and results.

The text of the collected data, raw data or synthesised data, is shown like this, in Helvetica font.

This data was synthesised each week into weekly reports and these were collated into the monthly reports presented in this appendix. The collations focused on the key areas which became apparent during Month 2 of the study. The key areas were: the student document (first principles); marks and assessments; group work ethic / process; our environment; support and criticism; listening skills; questioning skills; teacher comments and observations; tape / video recorder; specific events. The key focus area group work ethic / process was further analysed under the following additional criteria: group work process; discussion and explanation; background; tasks; noise; behaviour; help; homework; observations.

3.1 MONTHLY REVIEW #2: March - Weeks 5 to 7 (inc)

This next section presents the observational data collected during weeks 5, 6, and 7 of the implementation, Month 2. The data is delineated into the categories described in Table 1 in Chapter 3 and is similar in structure to Month 1. Within each category the data is presented in chronological order from week 5 to week 7. The category Group Work ethic / process is further divided into additional criteria as discussed earlier. Following the observational data, the data arising from specific events is presented. For Month 2 these include the results of the second MCI classroom environment survey and the Mid-Term 1 test, a report on group work in other subjects and Buddy reports (partial data as some students were away on camp and completed these reports subsequently).

3.1.1 The student document / re-focus on first principles.

Week 6:
The definition of group work is not clear to the students and needs to be discussed by the whole class.
3.1.2 Assessment.

Week 5:
A 'lightning' check for homework completion created uncertainty in some of the students but immediate feedback and discussion of the results led to their acceptance of the procedure.

Week 6:
The results of homework and 'mentals' are collected, recorded and briefly commented on. The teacher's light-heartedness eased the pre-test tensions as the test rules were outlined. Most of the students worked very well under test conditions although some restlessness arose after 20 minutes of the 30 minute test. The students engaged in very animated discussion at the end of the test. The test results were discussed and the need for the group to be concerned about everyone's results was highlighted. Each student should want to help their group members improve before the next test.
One student (Trudy) commented that she was doing better now than she used to do.

MCI
Some of the comments overheard when handing out the MCI included: "Oh no, not again". This may have resulted from the lack of feedback since the last MCI. The teacher explained what to do namely: Side 1 - "What is the class really like?" Side 2 - "What should the class be like or what do you want it to be like?". The students were allowed to complete the MCI in their own time and did so in almost total silence.

Discussing MCI #1 results:
The teacher discussed the group ratings sheets and made fairly light of the these results to de-emphasise the differences (see the transcripts of the comments - reported in Month 1). The students reacted mostly with amusement to the described results from the first MCI test not having seen themselves in such a light before (see the transcriptions of the comments on the overall class data - reported in Month 1). Some students queried the conclusions indicating that MCI does not always return expected results. A great deal of discussion erupted as the students compared and discussed their MCI results with their groups and throughout the class. A very happy / jovial mood is evident as they make their own conclusions about the results. The teacher reminded the students that these results were not used for grading but to survey their opinions which were so very important.

Week 7:
Student and group progress is monitored by the teacher as he moves around the room, asking questions and looking at the student scripts.

3.1.3 Group Work ethic / process.

Week 5:
The students are asked to use their imagination, close their eyes, to visualise in their mind the solutions to problems. This emphasises the links between seeing and doing and clarifies what is happening. The students are also asked to demonstrate their solutions physically
causing them to consider deeply what they are trying to illustrate, as they translate thought into action. They act out physically and explain visually on the board about solutions to problems. Some students have difficulty converting an idea from the physical demonstration, which they understood, to the theoretical equivalent, which they do not yet understand. The teacher tries to clarify examples in many, varied and practical ways. Some students are clear on it, others are thinking still.

**Week 6:**
The teacher also uses physical examples to try to highlight the differences between activities or to confirm a solution and explain the methods and concepts.

**Week 7:**
In one activity an analogy of the mathematical processes being examined, (shoe and sock on) was tried. The success of this was not assessed.

3.1.4 (a) Discussion / Explanation

**Week 5:**
Continuous discussions without resolution or direction and teacher expositions which involve lots of repeated assertions lead to confusion for some students even if the talk is based on a lot of student questioning, queries or ideas. After solutions to activities or homework are given and explained the students are sent back into their groups to discuss and analyse their own errors. Very strong discussion then occurs within the groups. Some students, clear on the concepts, had thought ahead and they put forward even simpler solutions to the teacher set problems.

**Week 7:**
Teacher exposition often contains many blanks which the students must fill in to get the full picture which encourages attention and thinking.

A detailed explanation takes time but seemed to be successful.

The teacher has a good rapport with the students as evidenced through several personal dialogues but most student queries are concerned about procedural matters. The students discussed a solution and through consensus decided that the text was wrong. Sometimes not sticking to the lesson plan and letting the group discussions run for a long time can be a valuable exercise. Other times the only way to consolidate the work is for the students to completely re-do a set of activities, highlighting the importance of the tasks.
3.1.5 (b) Tasks

Week 5:
The teacher sets the task of explaining the homework to each other in their groups.

Week 6:
When the reading level of the text is too high and the interpretation is difficult the teacher has the students define the terms used in the activity to further clarify the steps involved and summarises the students, the groups and the classes responses, to provide a framework or guide-line for the next activity. As problems of interpretation and so on are overcome the group work continues more quietly. When the students are uncertain on what is required a task is modified until it is clear. The students have to cope with multiple understandings as the teacher's language includes varied words for single meanings. e.g. rule = function = formula. The further we get into the term and the topics the more the students require help with new concepts.

Week 7:
When the students are set into a pattern of doing or a pattern of thinking they will run over into the next activity on automatic and struggle to see that it is different. The students tend to just follow the teacher through the steps when being led through a task. They do not appear to be always thinking about the task, just copying. This is no guarantee that they can do it. A teacher led activity was not able to be matched by the students so the teacher worked through another example. Most of the students were then able to complete the task on their own. A very detailed analysis was required for one activity and the students completed this themselves with the teacher's role reduced to that of scribe. The teacher asked if the students found this work easy. Most (10/12) said yes.
The teacher explains solutions by going through each detailed step to re-emphasise all of the concepts and reinforces the importance of some notes by suggesting that the students might note it down. Most students (not all) wrote it down. Even though only half the class are present (12/21) a clear polarisation in ability is evident when working these activities and a diverse range of preferences in methods is evident.

3.1.6 (c) Noise

Week 5:
Sharing is occurring but exercises tend to be dealt with quietly until students begin checking answers when they discuss the solutions within their own groups.

Week 6:
Initially there was quite a bit of noise as the students begin the set task. This mainly involves discussion of what to do and where to start. The students quieten down once they are into the task then discussion picks up again as they encounter difficulties.
Occasionally the reasons for this work ethic differ. You can get lots of discussion, some quite active, in all groups, when exercises are being done in class or you can get the 'silent' mode with less discussion than before but the cause is most likely the high level of problem difficulty.

Week 7:
The usual work ethic is in evidence.

3.1.7 (d) Behaviour

Week 5:
Sometimes despite teacher comments that they should work more in their groups the students remain quietly working while other times they begin discussing the work as they go on with it.
Even teacher 'absence' does not often enhance student discussion.
When doing exercises the students become unsettled after 30 minutes continuous working.
The students are very relaxed and talkative as they face time off class for a camp next week.

Week 6:
The teacher still needs to emphasise the group focus idea to enhance sharing and the initial tasks at the beginning of the lesson are still teacher defined.
To make the work less tedious the teacher can streamline the set procedures or require the whole group to report at the end of the activity.

Week 7:
Quite a lot of discussion arises when the students are given a limited amount of time to compare answers within their groups prior to the class marking the solutions. This time limit is not always given.

3.1.8 (e) Help

Week 7:
The teacher's explanation of a difficult example met with many student interruptions requesting clarification. The teacher tries to address every request and service every 'call for help' and give all who wished to have a say the opportunity to do so. Some discussion arose between the teacher and Camp Group 6 regarding the use of the correct steps. By posing the problem as a 'you have to do it that way, what can you use to make it work' situation the students saw how to do the correct steps without being directly told by the teacher how to do it.
When a group could not do the work the teacher stepped in to explain it, got them started then left them to get on with it and help themselves and each other clarify and consolidate the ideas. Groups in which most people cannot do the work are not very useful in group discussion of problems. The teacher moves around among the groups, discussing their
work, challenging their understandings, getting the students to clarify and express their ideas orally.

3.1.9 (f) Homework

Week 7:
The students discuss their homework solutions, either as a class, or quietly within their groups working together, comparing answers, getting ready for class based checking and they work silently on some mental questions, using calculators.

3.1.10 The environment - group size and effect.

Week 5:
Working ahead of themselves in a Vygotskian framework uses the collective energy of the group to provide proximal development for each individual student so that what was once out of reach in the proximal 'zone' is reached. This is achieved by setting new tasks of different styles even though old concepts are not yet clear to all of the students.
The students seem clear on routine matters but sometimes when these are extended they seem to lose the plot.

Week 6:
Extending an activity from an old topic further challenges the thinking and understanding of the students about the concepts involved.
The teacher variation in representing rules and demonstrating the 'correct' way may take the students beyond their proximal level.

Week 7:
The groups were restructured during week seven as nine students left for one week to go on camp. Groups 3, 4 and 6, usually four members, each lost one member. Groups 1, 2 and 5, usually three members, each lost two members. Therefore, the left overs, one each from Groups 1, 2 and 5, are appointed by the teacher to fill the one gap in each of Groups 3, 4 and 6. On appointment, they are advised of the teacher's desire that they 'spy' on, and at the week's end report on, the three other students they are joining in with. Their placements are based on the following criteria. The Group 1 student joins Camp Group 4. She is fairly reliable, conscientious and a good worker but she had earlier exhibited a lack of faith in her own group. They are the 'scatter-brains', the lazy ones, who were loosing their best worker. Perhaps they could show the 'new' student how lucky she is to be in Group 1. The Group 2 student joins Camp Group 3. She is quiet, strong, a good worker. They are a very good team but mathematically weaker. The union should produce an effective, on going, group environment. The Group 5 student joins Camp Group 6. She is quiet, reserved, fairly weak mathematically. They are a good team, boisterous at times, and like to discuss things. They could help bring her out of her shell.
3.1.11  Observations.

**Week 7:**
Camp Group 4 are working quite well together although, as they have more trouble than most, they tend to communicate more. Camp Group 6 are working individually and with virtually no communication. Camp Group 3 has one student who has nearly finished the work before anyone else has started as she got ahead yesterday. The others in her group are working fairly quietly but some discussion is occurring about answers as they compare results. Much help among Camp Group 3. Some help among Camp Group 4 though they are 'eaves-dropping' on camp Group 3. Camp Group 6 are working mainly individually and then helping each other as they get stuck. Camp Group 6 - did seem to bring the Group 5 student out of her shell. Camp Group 4 - very little change in this group but the Group 1 student seemed happy and to be working as well as usual. Camp Group 3 - a little less discussion than usual occurred here so the student missing, away on camp, may be an influence in this way. The Group 2 student did not seem to change.

3.1.12  Student support and criticism of each other and the teacher.

**Week 5:**
When the teacher analyses an incorrect student answer and uses this analysis to redirect the student's focus, the student can acknowledge that the original comment was an error yet still save face from the discussion. An example of this occurred with Gwen of Group 3. A student asked if they could do the up and coming test in groups. Response was - NO! The students expressed concern at this fact. Not necessarily supporting group work but, I suspect, more a case of 'safety in numbers'.
Students who come to the board to write up and explain their ideas and solutions tend to talk to each other or themselves but not the class.
The effect of protracted debates and uncertainty may make the environment quite subdued or this could result from the after effects of a long weekend.
The students are quite happy to dispute, discuss and analyse solutions and if necessary correct them.

**Week 6:**
Teacher observations of groups working: Groups 4, 5 - off task, cross talking. Group 6 - off task talking. Groups 2, 5 - not much sharing. Group 4 - 1 girl leading an off task example.
Group 3 - worked quite well together on the first activity.
The teacher made a comment to Group 3 on the high quality of their work and how they were earning lots of bonus marks. Group 2 was observed sitting in their original non-functional arrangement but the students seem to be working well.
All groups were working almost silently on activities. Group 4 helping each other a fair bit as was Group 3. Other groups were just occasionally referring to each other.
A happy industrious atmosphere was evident in the classroom as the students anticipated the return of their tests.

3.1.13 Questioning.

**Week 5:**
Conversations can be 'eaves-dropped' by students who may listen to get their own ideas clearer.
The teacher uses students to present solutions to the class as the focus for the discussion of the problems.
Sometimes whole class answers to questions need to be teacher summarised to ensure the answer is clear to the students.

**Week 6:**
Sometimes class discussion of solutions was based totally on student answers which involved collecting several responses to make the points clearer and determine their correctness by actually drawing them and testing them on the blackboard. This can provide instant response about right / wrong solutions as most of the input comes from the students.
The teacher tries to solicit responses from every student and not just the more willing contributors.
When several students give varied responses to an activity, or individual students ask about a particular point of the activity, or it is observed that some students are not doing the work correctly or are using incorrect procedures, the teacher will stop the whole class and check their work or the solutions so that the issues could be seen and discussed by all. Then alternatives can be re-emphasised in an attempt to modify the students' thinking and get them to think again.
When the students require help with the concepts the teacher can discuss their questions openly though for some, more careful reading of the text will help.
Some questions asked of the teacher were referred back to the group for resolution.
If the group can't answer a particular question it can be put to the whole class for solution.

**Week 7:**
The teacher can agree with incorrect responses or at least not reject them, which prompts the students into responding or commenting thereby creating a need for correction or adjustment or explanation. Examples of what the higher grade students do can enhance the worth of the work the students are doing now.
When the teacher stops the whole class it is in an attempt to get the focus to shift from individual or group understanding to whole of class discussion of the problems being met in the new and difficult activities and hence enable the groups to go on to try the next activity.
To be clear on the methods the students must express all facets of their working and solutions.
One student admitted not asking the group. When the student said 'I couldn't do this', the teacher set the group the task of explaining the process.

The two weaker students (Group 4) are still very teacher centred as they check each step and each answer with the teacher as they work through an exercise.

3.1.14 Teacher comments and observations.

Week 5:
The teacher tends to favour Groups 1 and 4 when seeking answers. Group 1 - most able? Group 4 - noisiest.

Using student demonstrations more often and observing the students when giving answers or discussing solutions can enhance the teacher's understanding of the students' conceptions.

When the teacher moves around the room, assisting, observing, quizzing, the groups as they discuss their work, the students will question more freely on various aspects.

By making set or fixed statements the teacher can preclude unproductive debate.

Trudy - Group 6 - seems to be coming out of her shell. Asserting her own definition of a word she found that several others shared it and she had wide support for the example she illustrated on the board.

Week 6:
Making loud verbal comments about 'off-task' behaviour to certain students is intended to limit only undesired behaviour across the classroom.

The teacher exhibited a very negative attitude towards some students who had 'errored' in some way.

These students were using manipulatives during the test: Cathy, Trudy, Wendy, Faye, Louise, Yvonne, Mary, Robyn, Penny, Emma, Denise and Amanda.

Week 7:
Two very weak students (Group 4 - Mary and Louise) did not work well in their Camp group and developed quite a degree of teacher dependence checking each step and each answer in an activity with the teacher. The teacher required them to get back to their group and get on with the exercises.

3.2 My Class Inventory (MCI #2) - week 6

Teacher's comments on MCI #2:  - this is a transcription.

Comments on class results: "The class thinks that we should have more satisfaction. We're not - everybody is not satisfied enough yet. We should have less friction, so there is a little bit too much 'aggro' in the environment. We should have less competition, so this is still a problem for us. We think that the work is exactly at the right level of difficulty - that is a major
significant result there; and we think that we need to be a little bit more cohesive, we're not all working well together as a total class, but we're close. Now those results are very close to perfect, umm so that is a good summary."

Comments on the group results: "You can see how the groups, how close the groups were. Group 6 - almost the perfect group, their graphs are almost exactly on top of each other this time. Group 3 - not to bad. Group 2 - pretty good. Group 1 - got a couple of differences. Group 4 - very good, just one difference in the amount of competition, there's too much of that in your group it seems. Group 5 - well they're all over the place, but they've got the basic shape so at least they agree on the basic ideas but they've got way too much competitiveness and not enough satisfaction and not enough cohesiveness."
The teacher suggested that things had improved between the first and second MCI results. The students mumbled agreement.

3.3 Group work in other classes - week 7

"Classes which I work in GROUPS in":

<table>
<thead>
<tr>
<th>NAME</th>
<th>SUBJECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hillary</td>
<td>Maths, Theatre Arts, Media Studies</td>
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<td>Faye</td>
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<td>Gwen</td>
<td>Maths, Theatre Arts, Media Studies, English, Computer Studies, Science</td>
</tr>
<tr>
<td>Emma</td>
<td>Maths, Theatre Arts, Media Studies, English, Computer Studies, Home Economics</td>
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Camp Group 6

<table>
<thead>
<tr>
<th>Stacey</th>
<th>Maths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trudy</td>
<td>Maths, Media Studies, English, Home Economics, Science</td>
</tr>
<tr>
<td>Vicky</td>
<td>Maths, Theatre Arts, Media Studies, English, Computer Studies, Home Economics</td>
</tr>
<tr>
<td>Robyn</td>
<td>Maths, English Development, Science</td>
</tr>
</tbody>
</table>

Camp Group 4

| Mary   | Maths, Theatre Arts, Home Economics, Science                          |
| Louise | Maths, Theatre Arts, Science                                          |
| Kerry  | Maths, Home Economics, Science                                        |
| Cathy  | Maths, Theatre Arts, Home Economics, Physical Education               |
3.4 Buddy Reports - week 7

Camp Group 3 by Emma (Group 2)

Faye - I see Faye as a kind person. In our maths group she always shares her answers and is willing to listen to the other girls.

Gwen - I see Gwen as a shy, quiet person. She works hard on her answers and problems when she has answered all of the questions she waits for another member of our group to give an answer first before she discusses hers. Maybe she is afraid of speaking up first because of her shyness.

Hillary - Hillary is quite humorous. She works out her answers very quickly but is very reluctant to participate. She is unwilling to discuss and share. But I like her!!

Camp Group 4 by Cathy (Group 1)

Kerry - Kerry is the leader of the group as far as work goes. She is sensible, tries hard and does her homework while the others copy. Unfortunately, Kerry sometimes doesn't understand things and gets very confused. The other two in her group tend to ignore her because they're too busy having pen fights. The only time when they consider her is when they need to copy her work so Kerry is sometimes left with not understanding things. Kerry is eager to learn and can get the groups marks to a higher position.

Louise - Louise has trouble with Maths basically because she doesn't understand it. She needs someone in her group that has a good knowledge of maths and who understands it and can be good at explaining questions. Louise often plays around in Maths mainly because she can't be bothered to do the work. If she had someone in her group that is good at maths and can explain it well, maybe she would enjoy it more.

Mary - Mary is very bright but doesn't know it. She is extremely lazy and doesn't do her homework but in class she is quite good and gets most of the questions right quickly. Mary is a bit of a rebel and the ringmaster of the behaviour problems. If Mary concentrated on her work more than her pen fights with Louise maybe she would be bright, pleasant, well behaved and a conscientious student.

Camp Group 6 by Robyn (Group 5)

In the group I was with for just a week I found that in some areas they work a tiny bit differently to my actual group I'm in.

Stacey - I think Stacey likes to keep to herself about things she knows in maths. But if she doesn't understand she'll ask the group, then try and figure out the problem.
Trudy - Trudy will work until she comes across something she doesn't understand then she'll ask the group what they think about it then ask how to do it.

Vicky - Vicky knows quite a lot about maths and will keep to herself a lot and usually finish before anybody else. Vicky is like Stacey and Trudy, she'll ask about something when she doesn't know how to do it or when she doesn't understand something and then try to figure it out. Overall they are all quite the same in asking and wanting to know the answer or problem.
APPENDIX 4

OBSERVATIONAL DATA FOR MONTH 3

This appendix contains the data collected during the third month of the implementation and is constituted of observations, reports and results.

The text of the collected data, raw data or synthesised data, is shown like this, in Helvetica font.

This data was synthesised each week into weekly reports and these were collated into the monthly reports presented in this appendix. The collations focused on the key areas which became apparent during Month 3 of the study. The key areas were: the student document (first principles); marks and assessments; group work ethic/ process; our environment; support and criticism; listening skills; questioning skills; teacher comments and observations; tape/video recorder; specific events. The key focus area group work ethic/ process was further analysed under the following additional criteria: group work process; discussion and explanation; background; tasks; noise; behaviour; help; homework; observations.

4.1 MONTHLY REVIEW #3: April - Weeks 8 to 10 (inc)

This next section presents the observational data collected during weeks 8, 9, and 10 of the implementation, Month 3, which takes us to the end of the first school term. The data is delineated into the categories described in Table 1 in Chapter 3 and is similar in structure to Month 1. Within each category the data is presented in chronological order from week 8 to week 10. The category Group Work ethic/ process is further divided into additional criteria as discussed earlier. Following the observational data the data arising from specific events is presented. For Month 3 these include the second set of reports on group work in other subjects, the second (week 8) and third (week 10) sets of Buddy reports, comments about the photographs which are spread through the thesis, a report on the first video review of a lesson, the results of the End of Term 1 test, a report on the observation of the class by a research colleague and the results of the first Classroom Learning Environment Survey, or CLES, a constructivist-based learning environment instrument.
4.1.1 Assessment

**Week 9:**
The students became very enthusiastic when the teacher started giving groups 'points' for answers and 'bonus points' if they could 'catch out' another group with an invalid method or incorrect solution.
At times the students respond very well when homework is checked for completion.

**Week 10:**
At other times they are not prepared to hand in completed homework.

4.1.2 Group Work ethic / process

**Week 8:**
The half class of students seem to lose their group focus a bit this week (second camp week) and the teacher had to emphasise that they should keep on working in groups and check their work with each other as they seem to be working very individually and not interacting at all.
The students went very passive and quiet during long periods of teacher exposition although some do interrupt to seek clarification, test their understanding or put their point of view. Some finished early and had to wait for the others to catch up so they could check their answers with their group. All the students contributed to the solutions by verbally describing their solutions for the teacher to scribe on to the board.

**Week 9:**
Frantic, intense, very vocal group work resulted as the students prepared a group report. They were very busy, chatting and collaborating, as they carried out the work in a good interactive style with a mix of helping and solo work. Various levels of group work are evident.
The class seems polarised as some groups have finished while others are still in the early stages of the activity. Each group has those who finish early and these people tend to tell the others the solutions rather than explain them.
Quite a bit of group work was going on as the students worked in their groups for a very long time, staying on task for most of it, busily working on the activities. They were given further time to complete the work, something which they do not get yet often need and they carried on whether the teacher was present or not.
The students worked through the test in silence sitting in their groups.

**Week 10:**
After student comment on the two previous MCI surveys the teacher pointed out that an average type of value was given to nil responses potentially making group work more valuable. The teacher commented that similar questionnaires came from the counsellors and that other classes could do them but probably this class were the only Year 8's involved.
Several students were confused by the term 'real-life' used in one of the CLES questions and (Louise) asked the teacher to explain her answer to her to see if it meant what she thought it meant. It did!

4.1.3 (a) Discussion / Explanation

**Week 8:**

Any discussion was individual student to teacher, not group to teacher or class to teacher and often started with the student who was most confused about the work. The students only contributed when asked and very little intra-group talk or discussion occurred. At least the discussions flowed freely albeit quietly when the students were sharing answers. A lot of discussion developed whenever the students struck trouble but once the students were clear on what to do they quickly quietened down and got on with the work and many self started by following the instructions on the board.

**Week 10:**

Group 1 finished discussion before anyone else and Group 4 were still discussing when the teacher intervened and went on to the next activity.

All groups were busy discussing, working out answers and explaining methods. In an attempt to strengthen their understanding all the groups became very active as they discussed and compared their ideas on the homework activity for their reports.

The teacher left it to the groups to make up every members knowledge on conversions through the discussion of activities.

A lot of group work occurred naturally as the students read through a student mathematics magazine publication trying various activities. They worked on the magazine activities with a lot of animated discussion, sometimes involving the teacher, mainly to clarify instructions.

4.1.4 (b) Background

**Week 9:**

The students made several comments about measurements showing considerable background experience or knowledge.

**Week 10:**

A student commented that a model the teacher demonstrated could often be found in Christmas crackers. Several others giggled their confirmation of this observation. Maths is evident in the students' non-school environment.

A lot of prior knowledge was evident as student input was used to form and lead a discussion of the Metric system of units and their relationships but the students practical use of this knowledge was not up to the same standard.

A broad base of knowledge was also evident for the Non-Metric system of units. Several students even know metric non-metric conversions, e.g. 1 in = 2.5 cm. The students
commented that their knowledge of non-metrics was from their personal experiences, that is strong cultural influences / experiences were evident.

4.1.5 (c) Tasks

Week 9:
The teacher outlined a problem aimed at linking the work done by the two 'Camp' halves which one half of the class had observed. All groups were asked to explain this result. The teacher stops the class to outline the next activity which allow some groups go on and others to go back and catch up on the unfinished work. The students were quite disorganised preparing for a test but most worked head down though a few wandering eyes were seen.

Week 10:
As students nominated a length unit, the teacher had them represent it using gaps between their fingers or hands, that is a practical, visual knowledge which they were very accurate at doing. The teacher measured the students' representation of the metre, 1 per group, using a metre rule, between the students' outstretched hands.

4.1.6 (d) Behaviour

Week 9:
Two students reported on their impressions of the Maths quiz night they attended and a collective group sigh indicated that the students were annoyed that the reports had to stop when the bell sounded to end the lesson but they were still attentive even after the bell showing respect for their peers giving the report.

4.1.7 (e) Help

Week 8:
When the teacher worked with incorrect student solutions other students helped correct the work. Indeed, multiple corrections were offered. The input of several students' ideas opened up a variety of uncertainties among the class. The students check the presented answers and discuss and suggest alternatives as required.

Week 9:
Some active, some passive, some solo and some students zoom ahead and don't worry about their group.
Some groups are very animated in their helping of each other especially Group 4 which had to work out how to do the activity among themselves as they did not follow the teacher's steps whereas most of the students listened to the explanations when given.
Week 10:
Group 6 (through Stacey) asked the teacher a question about the homework report toward the end of the discussion session. Kerry (Group 4) asked a question. Denise (Group 2) answered both of the questions. Penny (Group 5) asked a question, Mary (Group 4) commented, Cathy (Group 1) made a clarifying statement. Several others asked questions or clarified their ideas.
Students who were not completely clear on what to do were invited to ask the class for more information.

4.1.8  The environment - group size and effect.

Week 8:
The groups were restructured as eleven students left for one week (Week 8) to go on camp. Groups 1, 2 and 5, usually three members, each loose one member. Groups 3, 4 and 6, usually four members, each loose three members, although one (Hillary - Group 3) actually stayed at school but she did other problem solving type work alone in the class during this week. Therefore, the left overs, one each from Groups 3, 4 and 6, are appointed by the teacher to fill the one gap in each of Groups 1, 2 and 5. On appointment they are advised of the teacher's desire that they 'spy' on and report at the week's end on the two other students they are joining in with. Their placements were based on the following criteria. The Group 6 student joined Group 1. She is fairly quiet but a good worker; they are boisterous and don't always get along. Perhaps she could keep the team together. The Group 3 student joined Group 2. She is the leader of her group and could be a strong supporter for the team; they don't cooperate much and need to share more often. The Group 4 student joined Group 5. She is on the verge of being a hard worker or lazy; they are effective workers but mixed in ability. Perhaps they could help her to see how important working hard is. These groups Camp Group 1, Camp Group 2 and Camp Group 5, were relocated to positions closer to the front and the teacher to enhance communications.

Often when the groups were working well there is a lot of the 'class noise' type of discussion going on. Loud and multi voiced.

Week 9:
Groups were back to normal in week 9, after the camps of the last two weeks.
Several students used real micrometers to measure objects with after the teacher explained how the micrometers worked. Others are all over the classroom as they measure all sorts of objects with a variety of ancient measures. Lots of chatter, sharing, talking and discussing as they do this.
Most students used manipulatives, especially blocks, during their test.
Week 10:
When the students are in a different venue (Seminar room), to watch the video of themselves working, they are sitting in individual seats, spread randomly around the room and are not obviously in their usual group sets (see report at the end of this monthly review).

4.1.9 Observations.

Week 8:
Wendy seemed to withdraw and just coast along in the new situation. Yvonne didn’t get lots of help and sometimes looked lonely and left out of it. This experience won’t enhance her efforts much and won’t swing her to be more enthused about her work. Isobel was sick for 2 days and wasn’t really well enough on her return to take charge or want to take charge and help the group function. Hillary worked on problem solving activities alone in one corner of the room as she was here last week and covered the work then. She was promoted as an expert who could help other students as required but no one consulted with her during the week. It did come out that Hillary had seen, but not commented on, some special results to a problem worked in the previous week. She needs to speak out more. Camp Group 5 - the 'new student' is not focused on the work. Five minutes later - now sharing better. Narissa is in charge - still discussing as we start class discussion of solutions. Penny not in agreement. Camp Group 1 - all sharing the checking well - finished first. Camp Group 2 - still one student (the 'new' one) short - not comparing together. Five minutes later - now they are comparing - still discussing as we start class discussion of solutions. Camp Group 1 and Camp Group 2 - clear and agreed on answers. Camp Group 5 - as was the case yesterday this group had some problems with one student not understanding the other two students giving explanations. Group work on the next activity. Camp Group 1 working fairly well together. Camp Group 2 interacting but not as much as Camp Group 5 who are interacting and disputing but getting the questions done. Camp Group 1, having trouble finding the rules, are addressing a lot of 'noise' at the class about how they can’t get it while Camp Group 5 and Camp Group 2 are getting it. Camp Group 2 chose to do the harder questions (as they perceived them) first at the suggestion of one of their members. Penny (Camp Group 5) came up after the lesson to get some answers checked and more hints and ideas to help her understand the work. The group work was going well until Camp Group 1 started calling out various discoveries to the whole class. One student in another group, Camp Group 5, asked a very good question of the 'loud' Camp Group 1 group which could not be answered or explained away. Good counter measure by the Camp Group 5 student.

Week 9:
Group 4 - help given - needed straight away to re-explain what the teacher had asked the students to do. Group 5 - mainly doing individual work. Group 2 - talking. Groups 3 and 6 - some talk. Groups 1 and 2 and maybe some others - finished - and yet Group 4 are not yet half way through. Group 4 - chaotic organisation, trying to help each other. Group 1 - all
finished. Groups 3, 4, 5 and 6 - still going. Groups 3, 4, 5 and 6 reported on their reasons for the observation. Group 3 - (Faye and Gwen) presented a good idea. Group 4 - (Yvonne and Louise) presented a couple of ideas. Group 5 - (Penny) presented a good idea. Group 6 - (Stacey and Vicky) presented two very interesting ideas. The next lesson Groups 1 and 2 reported on their reasons for the observation. Group 1 - struggling to 'get it', the teacher goes to help and discovers they have the wrong idea. When re-explained they 'got it' very quickly and away they went. Group 2 - some helping, some solo working. Denise not collaborating and getting frustrated with the others. Group 3 - Some explaining, especially Hillary, good! Group 4 - some helping, some solo working. Group 5 - some helping, some solo working. Group 6 - helping and explaining to each other.

Betty moved to Group 3 to 'spy' on Isobel. Gwen moved to Group 1 to 'spy' on Cathy. Denise moved to Group 5 to 'spy' on Robyn. Narissa moved to Group 2 to 'spy' on Emma. Kerry moved to Group 6 to 'spy' on Wendy. Trudy moved to Group 4 to 'spy' on Yvonne, (see Buddy reports at the end of this monthly report).

Group 1 - (Gwen in) - Some help asked for by Gwen, mostly solo work however. Group 2 - (Narissa in) - Narissa checking them, they are working mainly individually. Group 3 - (Betty in) - focus on Betty. Group 4 - (Trudy in) - they are helping Trudy, discussion good. Group 5 - (Denise in) - very individual work. Group 6 - (Kerry in) - Group operating collaboratively as usual.

4.1.10 Student support and criticism of each other and the teacher.

Week 8:
The students have found some of this months work easier and they have made comparisons between their mathematics class work and work they had done in their Religious Education class. CROSS SOCIALISATION III!

When faced with a situation beyond their understanding the students were able to overcome this problem based on explanations which fitted their understanding as it is at present. In discussion the students were eagerly supporting each other, taking each others points up and developing them further until eventually they had all convinced themselves they were right.

The students discuss solutions, correcting and questioning as need be but they do not always do so. Some consult with the teacher and are told to consult with their group.

Week 9:
The students reinforce and support each other when they try to explain why they did things a particular way, their own way and they tend to ask more questions if a student is giving the presentation.

Week 10:
The teacher commented that he thought that this area (arguing or supporting) of group skill had improved and that the students were much better now at monitoring questions and
answers, agreeing and supporting each other or disagreeing and giving alternative responses.

4.1.11  Questioning.

Week 8:
When students are working on the board the rest of the class often casually chats and gossips until the student or teacher presenting the information is ready to discuss it. Compared to the first week's camp groups the second week's camp groups discuss less, had more teacher direction, seem less confused and seem to have less difficulty in doing the problems but they did not work or score as well on a repeated set of mental problems. There is much less questioning as these students seem clear on what they are doing perhaps because the teacher, in the discussions, circumvented problems encountered the week before.
During 'answer time' the students direct all of their responses through the teacher and will only engage in discourse when they disagree with the teacher or more significantly with each other. They accept multiple solutions depending on how the problem was interpreted and offer multiple corrections when solutions need fixing. Different students each contribute an answer or offer alternatives to the teacher's solutions which the teacher readily accepts. The students acknowledged, verbally or by nodding, that they were happy with the solutions and results. They ask clarifying questions when they are unsure of procedures.
As the teacher asked for some information a student interjected, halting the teacher in mid-sentence. The student didn't understand one part of the process. The teacher said, "OK, let's do part a) together". The teacher and the student worked through a part of a problem the student didn't understand with the student giving the answers and the teacher acting as scribe. The student was able to do the work as the teacher guided them through the steps - very proximal!

Week 9:
The teacher will discuss and re-discuss task requirements with the students, trying to ensure that they are clear. The groups should be doing more of this. The students are able to discuss the general processes being covered but the teacher and not the group is best at emphasising the main points. To more effectively spread explanations the teacher can loudly answer a question and thereby 'address' the whole class on a matter which may have been queried by several individual students.
4.1.12  Teacher comments and observations.

Week 8:
The teacher uses work from the past, work to be done in the future and activities parallel to some completed earlier in the topic to clarify concepts and illuminate current work. Such explanations are accepted by the students but not necessarily fully understood. Experiences with the same work last week enabled the teacher to better direct the efforts of this week's group. The teacher's use of a physical example had negligible value to most students although one made a comment which exactly paralleled the mathematical situation.

If a student gives an incorrect answer the teacher will try to analyse and correct it but not all incorrect student responses are addressed. The teacher will often admit that the presented solution is not the only possible one and give examples which show the process but don't actually work. A lot of such work is done orally with the students contributing ideas and solutions throughout.

Each student or group gets to provide a response and possibly write on the board while the others correct the solutions when required. Rapid consensus is reached by the students when working this way.

Week 9:
The teacher repeated a student's (Jenny) activity from last week highlighting how well she had described her work. This comment was missed at first as things are rushed over at times as some lessons lose too much time to teacher talk and general organising.

In setting tasks for the students to do in groups the teacher will have to help groups where no one knows how to do a particular type of question. The teacher is moving around the class guiding, assisting, checking student work, correcting, helping the students as required, monitoring them to ensure that they have sufficient directions to follow through the examples. When the teacher demonstrates things the students will then do likewise among their own groups.

Student answers are used to review an activity set, discuss a solution or check the solutions to a problem or some mental, for checking the homework and various exercises or to explain the problem. The discussion of student answers can aid in clarifying understanding and confirm to the students that their ideas and results are correct which encourages them to go on with the activity.

Sometimes pleasant personal conversation occurs and the students and the teacher share humorous discourse which indicates that a good personal rapport exists between the students and the teacher.

The teacher praised Camp Set 2 for finding an unusual relationship and was critical of Camp Set 1 who had made the same observation but did not report it.

Week 10:
Teacher talk and the organising of the lesson takes a very long time (too long ??).
One student (Trudy) was considering a tutor but the teacher indicated he thought the student could do better and without a tutor. It is the student's decision.

The teacher discussed the completion of the CLES survey and the procedure to be used suggesting that it might not have the repetition of questions which the students observed in the MCI questionnaires.

A student asked when she could have her test back and the teacher returned it to her during the recess break, reinforcing caring ties.

4.1.13 **Tape recorder and video recorder.**

**Week 9:**

Behaviour during a video taped lesson was 80% normal. Group 4 played up a bit but the others were fairly normal. The teacher explained why a video was being taken and why a photographic record of who is in each group would be made. The students were keen to see these later.

**Week 10:**

The teacher introduced the observer as someone who will observe and write notes, as the teacher does, about how the class works, how good the groups are and how bad they are.

4.2 **Group work in other classes - week 8**

"Classes which I work in GROUPS in":

<table>
<thead>
<tr>
<th>NAME</th>
<th>SUBJECTS</th>
</tr>
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<tbody>
<tr>
<td><strong>Camp Group 5</strong></td>
<td></td>
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<tr>
<td>Narissa</td>
<td>Maths, English, Home Economics, Japanese</td>
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<tr>
<td>Penny</td>
<td>Maths, Theatre Arts, French, English, Home Economics, Science</td>
</tr>
<tr>
<td>Yvonne</td>
<td>Maths, Theatre Arts, French, English, Science</td>
</tr>
</tbody>
</table>

| **Camp Group 2**                             |
| Amanda  | Maths, Theatre Arts, Media Studies, English, Science |
| Denise  | Maths, English, Science, French               |
| Isobel  | Maths, Media Studies, Japanese, Science       |

| **Camp Group 1**                             |
| Jenny   | Maths, Theatre Arts, French, English, Home Economics, Science, |
Media Studies, Social Studies
Betty Maths, Theatre Arts, Japanese, English, Home Economics, Science,
Media Studies, Social Studies
Wendy Maths, Theatre Arts, French, English, Home Economics, Science,
Media Studies, Social Studies

4.3 **Buddy Reports: Group reports - week 8**

**Camp Group 1 by Wendy (Group 6)**

Day 1: Jenny: All homework has been done and looks all correct. A bit messy though. Betty: Did not have book. Not sure if homework is done. Combined: They worked together extremely well doing the tasks. Betty will do five and Jenny will do the other five and then they will give each other the answers they had come up with.

Day 2: Jenny: All homework has been done but is fairly messy. Betty: Book still missing and not sure if homework has been done. Combined: Same as yesterday. Working together with the same method.

Day 3: Jenny: Homework hasn't been done so Betty gave Jenny her book (now found) to copy the answers off. Betty: Found her book! Homework has been done. Looked fairly neat. Combined: Both came up with good points today in Maths when we were doing exercises. Used combined effort again.

Day 4: Jenny: Worked well by herself. Did not do very well in mental. Betty was away today. Combined: Jenny did fairly well with book work.

Day 5: Jenny: Has done homework. Contributing to class activities well. Betty: Has done homework even though she was away. Combined: They are both here today. Overall: They work together extremely well and get their work done quickly.

**Camp Group 2 by Isobel (Group 3)**

Amanda is very smart but just not as smart as Denise. Amanda depends much more on the group than Denise does. Sometimes it looks like she struggles a bit but other than that she seems to be doing well. With Denise it is different as both Denise and Amanda are smart but Denise is very quick. Like if you told her a sum that she knew how to do, she would work it out very quickly. Also, Denise is very sneaky like sneaking food into class. So it seems to me that Denise and Amanda are doing well in their maths.
Camp Group 5 by Yvonne (Group 4)

Narissa is not used to working in a group and doesn't check answers with the other members of the group. Narissa understands most maths. Penny also isn't used to group work and gets a bit mixed up when describing things in class. Penny doesn't understand work very well and needs it to be explained a few times. Penny did well in mental. Understood a lot. Penny is good at mental (BIMDAS) but doesn't understand very well and asks lots of questions.

4.4 Buddy Reports: Solo reports - week 10

Isobel by Betty
Isobel is a hard working student. She concentrated on what to learn and when she understood she made sure everyone else understood and then went on with the activities. I think she puts in a lot of effort, compared to some other students. On top of all that Isobel manages to have a smile on her face all day.

Group 3: The group made me feel very welcome. We worked together well and we had fun but the work was quite easy anyway. But there was one thing in my actual group (Group 1) which was that if answers were disagreed on, we would compare them, do the working out again, get the right answer and show the other person what to do. In this group (Group 3) one of the members was very uncooperative and she did not let anyone else look at her work because she disagreed. She would let us help her and she did not work with us as she raced on and asked us to call the answers out.

Cathy by Gwen
Cathy is quite quiet and not too pushy. She is O.K. and pretty clever. I think she was just acting nice because I was there. She isn't usually all that nice. She didn't do all that much and she wasn't much help.

Yvonne by Trudy
Yvonne is a good worker who really tries hard but when she loses her concentration you need to try hard to get her back on track. Overall she is a good worker and if she really concentrated her work would be outstanding.

Wendy by Kerry
Wendy works, in her group, very well. When she thought differently to the group she would bring it up and explained it to the group so they would understand and usually she was right. She was quite quiet but she did get the group to listen.
Emma by Narissa

Emma gets curious and she becomes quite nosey. She gets ready for work quickly and quietly before the second bell. She works very well with her group, but sometimes is quiet and won't contribute. Emma complains that Denise does 'solo' work and doesn't contribute to their group. She discusses with her group with an understanding knowledge.

Robyn by Denise

I think Robyn is fairly valuable to the groups discussion. She will not butt in when everyone else is talking but wait to the end. She will easily agree with any solution if they can make it look better than hers. She seems to enjoy the people in her group and she is fairly friendly. She will let everyone say what they want.

4.5 Video report - week 9

Video begins prior to the first bell with the teacher and students getting settled. Some students are handing in various items of homework.

This is the first full class lesson after two weeks of half in class half on camp lessons.

Several across group conversations are evident. This supports the concept of wide ranging friendships within the class.

Bell goes.

The students quieten down (their attention is within their groups), the teacher greets them (the students' focus is now on the teacher) and explains the video recording.

The teacher asks where the missing students are, various responses, the teacher looks out the door and up the passage, (showing caring / concern or authoritarian behaviours?)

The students' attention remains focused on the teacher as the teacher addresses the class on several 'tie together' issues. One student (Yvonne) is flicking through her file and book assumedly organising things for this lesson.

A student asks - 'what's on Wednesday?', to which several others respond - 'the test!!'.

Some anxiety and emotion is evident as 'the test' is commented on.

The students open their texts as the teacher selects the page. Some students comment to each other as they look at that page.

The teacher asks for an answer and one student (Penny) gives it. The teacher asks - 'why am I upset when I say, when I see that?'. This causes several students to look up to the board and one (Denise) responds with the correction required.

The students were mainly focused on their texts prior to the teacher's question.
As the teacher goes through the exercise on the board, those students in view are following the work in their texts.
The teacher continues to seek information from the students to develop the solution. One student (Cathy) gives a suggestion, the teacher just nods to facilitate further explanation from that student. The teacher gives additional verbal prompts and the student completes the question.

The students are noting down what to do in their texts. They are very quiet as they follow the teacher led exposition.
One student (Betty) volunteers a solution. The teacher calls her 'one foot' as one of her feet is injured. Other students can be seen looking over to her to see why the teacher said this.

The students are focused on either the teacher and the board work or their texts and they tend to swap between as they listen, note down and so on.
The teacher is very animated in explanations and moves around the front boards quite a bit when explaining.
The students are very teacher focused as the teacher explains an analogy.
The teacher has a very 'happy, smiling' disposition.
The teacher comments again as to what the 'one foot' person (Betty) had done to her foot causing all the students to look in her direction as she explained she had sprained her ankle.
The teacher commented on something a student (Jenny) had said last lesson. The other students glanced in her direction.
The teacher's comments and particularly the naming of students directs class attention to focus on these students.

The teacher instructs the students to go into group mode to work on the activity.
The students are working in groups:
Group 3 - two students (Faye and Gwen) are discussing questions.
Group 4 - is discussing each question as they work through, then the fourth member of their group arrives (Kerry). The teacher hands her some documents then explains that her group can catch her up on what we are all doing.
Group 2 - individually working
Group 1 - discussing something (didn't look like Maths).
Group 3 - sharing some thoughts.
Group 6 - individually working
Group 5 - mainly individually working
Group 4 - the students are explaining to the 'recent' arrival what to do, then are just chatting about something.
Group 5 - Narissa is explaining and helping Robyn with a problem with Penny looking on and then querying Narissa's comments.

Group 1 - just talking, not much Maths.

Group 5 - working on problems.

Group 4 - a hand goes up (Yvonne) to ask the teacher a question.

Group 2 - one student (Denise) is monitoring the progress of her group members.

The teacher is helping out in Group 6.

Group 3 - some discussion as they work on the questions.

Group 6 - some discussion as they work on the questions.

The teacher explains to Group 4 what they are meant to be doing as none of them seemed to be clear on the task.

Group 5 - some discussion as they work on the questions.

Group 1 - the teacher checks their progress - finished - the teacher and one student (Jenny) discuss the Maths Quiz Night which the student (Jenny) had attended.

As the teacher addresses the class on the next task, several students, e.g. all of Group 4, worked on with the present task until the teacher impressed upon them to focus on the next activities process.

The students are following the teacher and the text as the next activity is outlined.

The students freely and openly join with the teacher and participate in a set of calculations as a new idea is developed.

The teacher is very animated up the front of the class as an activity is done.

The teacher gives quite a lot of oral instructions for the students to copy and follow. These are not always duplicated in written form on the board. The students often verbalise answers in a semi discussion format / conversation with the teacher.

Betty and Jenny give the teacher the requested answers. Notice how they have been the dominant focus for the teacher up to this part of the lesson (and in fact continue to be a main focus for the rest of the lesson).

Group 1 - already doing the next exercise set as the teacher sets the task for the class.

Group 2 - Emma (and the others in the class) turn back to the old activity to complete it and discusses solutions with Denise as Amanda listens in.

Group 5 - doing and comparing solutions.

Group 4 - doing activity

Group 3 - doing and discussing some answers. Isobel helping Gwen.

Group 6 - working mainly individually. Trudy is seeking Stacey's help. Stacey confers with Vicky.

Group 4 - mostly working on the questions. Mary is a bit 'camera aware'. Yvonne and Kerry are explaining out loud and to each other while Louise listens in and works on the questions
herself. Mary asks Kerry for help then moves around to her side of the desk to discuss the questions.

Group 2 - Amanda is discussing with Denise as is Emma. Mainly going on with the exercises individually.

Group 3 - Isobel is further helping the others in her group.

Group 5 - mainly working individually.

The teacher is moving around the room checking on homework and so on while handing back previous homework.

Group 1 - some discussion as they work on the activities.

Some discussion within groups, Group 4 observed, of the homework sheets handed back.

Group 4 - students, Kerry and Mary, still working together on the activity with Louise listening in.

Group 6 - still working on the problems, checking and discussing the homework sets once returned.

Group 3 - Faye seeks a solution from Hillary. Hillary explaining to the group. Gwen and Isobel discussing solutions then all on with individual work.

Group 2 - Amanda working on problems as is Emma, checking with each other and occasionally with Denise, but doing each question individually first.

Group 4 - still working on the questions. Kerry and Mary discussing. Yvonne and Louise individually working.

Group 5 - checking over and discussing homework. Narissa explaining something to Robyn.

Penny working on with the activity questions. Narissa and Robyn are working individually.

Robyn conferring with Narissa on a problem.

Group 1 - working on the activity, each doing the problems and discussing them simultaneously, as they go, sounding out each problem orally.

Group 4 - the teacher is present, helping Louise. The other three students are discussing one of the problems. The teacher is completing the question for Louise as she gives the correct responses along the way.

Group 2 - discussing the problems.

Group 5 - working individually then Narissa helping Robyn.

Group 4 - Yvonne listening to the teacher assisting Louise and waiting for the teacher to come and answer her question. Mary requests the teacher's help so the teacher moves over to discuss further with Mary and Louise joins in. The teacher leaves and the students get on with the questions and discuss the problems.

Group 3 - a student (Isobel) has her hand up to request help from the teacher. She is not seen by the teacher.
Group 5 - seem to be working mainly individually on problems, conferring sometimes then
Narissa and Robyn get involved in lengthy discussion.
Group 1 - finished the activities so the teacher suggests they check their solutions from the
books answers.
Group 2 - Emma checking answers with Denise then focuses on the video camera which is
next to her. Denise is waiting for the others to finish. The video camera moves around past
Group 2 and some more interaction occurs, temporarily.

The video camera moves around the class and the operator (a research colleague) stops to
assist Isobel (Group 3) who had earlier requested teacher help and not received any.

Group 5 - more individual work mixed with discussion.
Group 4 - quite a lot of discussion as lot seems that all the members of this group are having
difficulty with this work. The students are very animated and spend the majority of their time
talking through the questions. This takes longer but by collaborating they can then do them.

The teacher interrupts the class to get volunteers to come up to the board to put up the
solutions to the problems everybody has been working on. The groups get to determine who
will put up their solution.
Emma (Group 2), Hillary (Group 3), Louise (Group 4) and Penny (Group 5), put up the
answers.
Despite being told twice that she was to put up the answer to question 2 and even being
directed to a section of the page by the teacher, Louise manages to put up the solution to
question 1 instead.
Hiliary has some confusion about what it is she should be writing and so goes back to her
group to confer. HA! She is far to individual in normal work situations. Perhaps this
illustrates how she would be better off if she conferred more with the group.
The video focused on Penny putting up her solution to question 5.

From the sound-track: The teacher suggested that everybody else might like to watch the
boards to check the work.
The teacher reminded the students to correct and mark with red pen to reinforce their own,
hopefully successful, efforts.
A discussion occurs between the students, mainly Group 6, and the teacher, about the up
and coming test. Very light hearted discussion. The students ask a total of 9 questions
most of which receive a "Yep" or "Nope" type answer from the teacher, who is down playing
the concern about the test.
Back on video: The teacher checks with the students about the solutions. The class informs the teacher that question 1 is done and question 2 is not. The teacher gets a Group 6 volunteer (Vicky) to put up the question 2 solution.

Much general class room chatter occurs throughout this board writing and checking session. The students check the answers.

Some discussion arises about the answer $2^{\frac{3}{2}}$. One student (Denise) asks if the answer can be 2.6. The teacher says that 2.6 recurring would be a better answer. The student says the answer has a seven in it. The teacher accuses the calculator of misleading the student. Some students ask if lines can be used instead of dots to show recurring. The teacher agrees that this is valid.

Quite a deal of open conversation (not instruction) occurs about this point.

The teacher questions a student (Jenny) about a solution she had written. All other groups and students listen to her response which leads to another of her group (Narissa) who then responds briefly to the teacher's ongoing questioning of the solution as written and as worked out by their group (Group 5).

Meanwhile, one student (Betty) is working in her text while another (Emma) is playing with her file.

Group 5's answers are incomplete so the teacher throws the question to all.

Another student (Isobel) comments against a barrage of 'Why?'s' from the teacher as the details of the solution are worked out.

Group 4, and maybe Group 6, are not really focused on the discussion which has become more of a private thing between the student (Isobel) and the teacher. As the questioning broadens, more students refocus on what is being said.

Teacher exposition summarises the discussion.

On checking who has completed the next activity, the teacher directs the students who have not, to do so, while the rest mark their work and go back and check over earlier work.

All groups seem to be busy conferring and checking and doing questions.

Group 2 - Emma discusses a problem with Denise then they seem to get on with individual work.

Group 4 - considerable discussion and sharing of answers. They do not appear to notice the movement around the room of the video camera.

Group 1 - discuss some aspects of the work with the teacher and among themselves. The teacher fills the role of an additional group member rather than 'a teacher'.

Group 5 - quite a bit of discussion about the solutions, sharing working and answers. The
discussion seems to get distracted to non maths then Narissa tries to get the group back on
task.
Group 1 - still checking things, questions, ideas and so on, some with the teacher. They
collaboratively work out where they are up to then the teacher goes and they converse about
some more of their solutions.
Group 2 - Emma and Amanda are working individually on the questions. Denise has already
finished. Emma gets up to go to the teacher to ask a question. (Why didn't she ask
Denise?). Denise working individually.
Group 5 - mostly individual work with Narissa helping Robyn again.
Group 4 - working collaboratively on the activities, discussing the problems. Louise getting
answers from Yvonne.
Group 3 - the teacher is conferring with Hillary. The teacher leaves. The group are working
almost all individually.
Group 6 - Some conversations, as the teacher goes past and checks their progress. The
group discusses the teacher's comments then seems to get back to doing the problems
mostly individually.
Group 4 - working (Yvonne and Kerry), watching (Mary), working (Louise).
Group 5 - chatting, do not seem to be on task at this glance. Penny is working individually.
Group 2 - Amanda and Emma are working individually.
Group 1 - Jenny and the teacher are involved in a discussion of the text solutions and errors.
Group 5 - working individually
Group 4 - working collaboratively
Group 3 - working individually
Group 6 - working individually, although Stacey and Trudy collaborate occasionally.

The teacher stops the class to address the students.
The students note what is said about homework and begin to sit back and relax as the
lessons end nears.
The teacher invites two students (Yvonne and Jenny) to address the class about the Maths
Quiz Night they attended last Friday. As they do so (Jenny mainly) most of the other
students in the class sit back and look at the speaker paying attention to what is said.
Amanda (Group 2) and Robyn (Group 5) are observed to be still working on problems in
their text book.
The bell went but the discussion of the quiz night was still occurring so nearly all the
students maintained their attention on the two students talking.
VIDEO FADES OUT.

Special Note: Groups 3 and 6 were not often in the cameras field of view and hence they are not observed as often as the other groups.

4.6 A review of the students watching the video.

- laughter at the antics of other (and self) students.
- the students are mainly trying to see themselves and others and their groups as the video rolls.
- The students comment about the class noise levels. High before the first bell, then it drops after the bell and as the teacher begins to talk.
- The students comment on how they look 'different' on video.
- The students agree that the teacher does tend to talk too much in a lesson.
- The students are viewing the video with amusement, quietly watching, making some comment, often laughing at what they see.
- While in fast forward mode the teacher commented 'now don't you wish the teacher worked that fast?' to which some of the students replied 'don't you wish we worked that fast?'
- The teacher pointed out where the instruction had changed to answer seeking.
- The students try to identify who, among them, is talking on the video.
- The teacher re-explained a point on the video which was a re-explanation of a point made in a lesson before the video lesson as some of the students agreed the concept was easily missed and they still had not understood it.
- The students laughed at the teacher's antics on the video.
- The students queried the video's workings and the teacher commented on these practices and when quizzed on their knowledge of such things several of the students indicated that they did have experience of them.
- Much laughter observing each other in the group work phase of the video.
- The teacher made some comments on what was being seen and observed.
- The teacher asked if the student in the video with her hand up was asking an individual or a group question. The student concerned claimed it was a group question.
- The teacher commented that he cannot just sit around and observe students because help is needed by groups when all of the members are unsure of what to do.
- The teacher diminishes the embarrassment factor for some students by quickly commenting on other observations whenever such scenes arise.
- More student reaction to each others antics on the video.
- The students agreed with the teacher that the behaviours being observed were fairly normal because, the students said, they quickly lost contact or awareness with the fact that the video was there.
- The teacher and the students comment generally and further on actions seen on the video.
- The teacher commented on the observed work habits of some groups.
- The teacher commented on how some students tell answers rather than explain answers. A student (Mary - Group 4) replied that 'when someone gets lost in your group and you guys are ahead of them you don't have the time to explain to them what you are doing...': This generated various comments (murmurings) from the members of her group.
- More general observations generate a lot of laughter from the students.
- The teacher pointed out the problems of video recording the white board during a section where the students are putting answers up for the class to check over.
- The students asked if this video would be shown to others, e.g. student teachers. The teacher said that this was for our use only, to make sure the class is working correctly.
- The students seem generally pleased that they have been able to see the video.
The focus of the students was dominantly on each others and their own physical appearance and actions, not on the pedagogy.
None of the students made notes or wrote comments about the video.

4.7 Observer report - week 10

Observation Session #1: - this is a transcription of the observers fieldnotes.

N.B. [] indicates added comments made by the teacher and approved by the observer.

Students wander in, some ask the teacher questions about their homework, others check their work in groups, some chat, get files organised.
Lesson started 9:20 a.m. Teacher talk about homework, excuses. Students watch board. Given four minutes to discuss in groups to overcome confusion and then hand in the next lesson.

Observations made at a distance:
Group 1 - One student didn't understand [Cathy] how to get the rule and asked the others, they explained.
Group 2 - general discussion, appeared to be unsure of the rule procedure.
Group 3 - Two students discussing [Hillary and Faye] two students listening, then one [Isobel] asked the teacher about procedure.
Group 4 - Three students participating in discussion, one student [Louise] listening, [Mary] read out one report [Kerry's].
Group 5 - One student [Narissa] writing, other two swapped written reports.
Group 6 - general discussion, one [Stacey] leader who explained the rule procedure to the others, leader checked with teacher.
Class discussion:

Students seem happy to ask questions of the teacher and improve their understanding. Group 5 student admitted not knowing how to get the rule but didn't get an answer from the teacher. (Hoping to encourage answers in Group). Teacher explains procedure, students ask questions and reports are to be handed in next lesson.

Collected tests back.

Kerry and Mary are asked a lot of questions.

From group discussion and teacher led discussion the students do appear to be extending their knowledge base. They are querying, questioning, explaining, using examples, trying alternatives until they have got the right idea.

New work - the metric system (consolidation of mm, cm, m) and discussion of the imperial system and conversions (yard, inch, mile). The teacher led the discussion on the board.

Only a few hands go up to answer a question but if the answer is wrong then most voices object. (that is students may not volunteer to answer but they are involved in working out the answer).

Some confusion about metric conversions still exists and exercises are done to consolidate. [never done in maths before therefore the view that this is consolidation must relate to the way the students responded which must have been based on their existing knowledge and experiences]

Students work in groups.

Observations made while walking around room:

Group 1 - Arguments (productive discussions) over answer as they try to agree, put each point of view, question each other.

Group 2 - One student [Denise] tends to supply answers first and then the others agree / disagree / write the answer down.

Group 3 - Work individually on written answers and then discuss.

Group 4 - Two students discussing then the others put in their views to reach a consensus.

Group 5 - Tended to write answers and then discuss, listening to one student mainly.

Group 6 - One student is teaching another and explaining moving the decimal point.

Groups 1 and 5 compare some answers.

Bell goes, homework assigned, students pack up and go.
Teacher's comments on CLES #1: - this is a transcription.

You've got your private copy there so you can see your graph, you can see your other group members graphs and see if they're the same shape as you if they're the same shape they think like you think and you can see your groups graph at the bottom and you can see the classes one.

Have a look at the last graph please, have a look at the last graph, the one in the bottom right hand corner, that's the classes graph.

Now this is what the letters stand for. There are only four in this one, this is different from the other one you did.

The first one is Negotiation, the second one is Prior Knowledge, the next one is Autonomy, (A student asks; "What's that?" The teacher responds "I'll explain it in a second"), the last one is Student-Centredness.

Now the box is what you would like, the diamond is what you think it is like so we're not yet, as a class, good enough on those categories.

Negotiation - you would like more opportunity to do the work and generate the work yourself. You think there are some people who are taking control too much and you need more chance to communicate and talk and negotiate what's going on in the environment.

Prior Knowledge - you think the maths class does not take advantage of your Prior Knowledge. In other words what you know isn't being valued enough. Now the opposite side to that is perhaps what you know is you don't know enough and you would like to know more so that you can get through this easier. So the reason that's the biggest gap is either because we're not using what you know or you don't know enough and that's frustrating you.

Autonomy - they're pretty close, that means your freedom. Do you feel that you are free within the class or within your group to get on with your work, or is your group free to do likewise?

Student-Centredness - means does the work focus on you the student or does it focus on some other part, maybe the teacher, maybe the topic if the work is too topic centred. Now you guys would like a little bit more of the work to focus on you and a little bit less on maybe the teacher or whatever.

Group 1 - followed the class trends fairly well.

Group 2 - again the Prior Knowledge. Interesting, you see I would have said that there were some girls in Group 2 who weren't as good at the maths as they would like to be therefore you get a big gap in Prior Knowledge because we're not using what they know or maybe we're just too far ahead and when we get into the work they feel lost.

Group 3 - is the same sort of trend as Group 1.
Group 4 - even more so. See their second one is a big gap. Maybe the class is working too far ahead of Group 4. They can look at their own private graphs and work out if that's true or not.

Group 5 - is the only group who actually would like less Autonomy. They would like someone to come in and control them more whether it be the teacher or whatever they don't all want more freedom, they feel a little bit more control might help them.

Group 6 - is the same sort of trend as Group 1 and Group 3.

So that's how we get our overall class results from those things there.

So we will do this longer and sort of more difficult survey (the CLES) again at the very end of next term.

In summary then you would like some improvement in all scales.

Negotiation - 27.6 to 30.0 - You would like more opportunity to Negotiate within the class.

Prior Knowledge - 24.1 to 29.8 - The class would like the lessons to take their Prior Knowledge more into account. You would like the lessons to better reflect your Prior Knowledge.

Autonomy - 22.6 to 24.8 - The students would like a little bit more Autonomy in their class environment.

Student-Centredness - 14.4 to 16.1 - The class would like a little more of a student focus in their lessons.

Notice that you value Negotiation and Prior Knowledge slightly more than Autonomy and that Student-Centredness is the least valued scale.

Prior Knowledge (difference of 5.6) has the largest variation between the students' preferred level and the perceived level.

Negotiation (difference of 2.4) has the second largest variation between the students' preferred level and the perceived level.

Autonomy (difference of 2.2) has the second smallest variation between the students' preferred level and the perceived level.

Student-Centredness (difference of 1.7) has the smallest variation between the students' preferred level and the perceived level.

Jenny - "I don't like those tests". [Someone else heard to say] "Yeh".

"Yes well, I'll tell you, just remember what we said at the beginning of the year.

We want to know what you think about how this group work is working because you are learning and if you read what the Principal wrote in the school newsletter (learning to learn is our objective), the most important thing that you should be learning in this maths class is not just maths.

The most important thing you should be learning is how to learn.

[ Bell sounds, lesson ends].
APPENDIX 5

OBSERVATIONAL DATA FOR TERM 2

This appendix contains the data collected during the second term of the implementation and is constituted of observations, reports and results.

The text of the collected data, raw data or synthesised data, is shown like this, in Helvetica font.

This data was synthesised each week into weekly reports and these were collated into monthly reports, the highlights of which are presented in this appendix. The collations focused on the key areas which became apparent during Term 2 of the study. The key areas were: the student document (first principles); marks and assessments; group work ethic / process; our environment; support and criticism; listening skills; questioning skills; teacher comments and observations; tape / video recorder; specific events. The key focus area group work ethic / process was further analysed under the following additional criteria: group work process; discussion and explanation; background; tasks; noise; behaviour; help; homework; observations.

5.1 MONTHLY REVIEW #4: April / May - Weeks 11 to 13 (inc)

The next section presents highlights from the observational data collected during weeks 11, 12, and 13 of the implementation, Month 4, the beginning of the second term of our four term school year. The data is delineated into the categories described in Table 1 in Chapter 3 and is similar in structure to Month 1. Within each category the data is presented in chronological order from week 11 to week 13. The category Group Work ethic / process is further divided into additional criteria as discussed earlier. Following the observational data, the data arising from specific events is presented. For Month 4 these include a report on the second video review of a lesson and a report on the observation of the class by a research colleague.

Group Work ethic / process.

5.1.1 (a) Discussion / Explanation.

Week 11:
The students chat and discuss their work freely, are friendly and happy and very busy in their groups.

As they attempt these activities good discussion accompanies development of the concepts.
The students are continually explaining, discussing, questioning, debating and conjecturing. There is clear evidence of student discussion leading to re-negotiation, peer teaching and so on to determine the correct solution.

**Week 13:**
The teacher interacts with the groups as they work through questions and the students volunteer answers in what can become a very animated and interactive discussion, a sort of "all in" affair.
The discussion of solutions produced an uproar as the students fiercely debated different answers. The teacher had trouble regaining control. The controlled debate did not resolve the issue and it was left hanging for later. Those in the debate were Amanda, Stacey, Gwen, Narissa, Yvonne, Jenny, Penny, and Kerry with still more trying to have a say subsequently.

**5.1.2 (b) Background.**

**Week 11:**
Some groups have a potential advantage if someone in their group is familiar with the material. The work can be beyond the experience level of the students and then they need more knowledge or assistance before they can complete the task.

**5.1.3 (c) Behaviour.**

**Week 12:**
The students sometimes work individually, such as on an outdoors activity, or even take over the running of the activity, instructing and explaining to each other, directing the teacher through a task or providing definitions to various ideas as we come across them.

**5.1.4 (d) Help.**

**Week 12:**
A student asked the teacher to clarify a process but a member of her group intercepted the query and showed her what to do. Good group help - Group 4, Louise helping Kerry! - it is usually the other way around!
The students provide help through answers which develop the ideas in the teacher's explanation.
The students corrected the teacher over the interpretation of an activity.

**5.1.5 (e) Month review - Group Work ethic/process.**

**Week 11:**
Quite an interactive rapport exists between the teacher and the students.
The students are quite relaxed about opening up and talking mathematics.
The teacher made the comment 'Good results in that topic you've just done ladies, very impressive'. The students can be heard to reply 'thank you, shouldn't flatter us'. The teacher says 'oh, flattery when flattery is due, bust you when I have to'. [Seems to be a fairly normal relationship].

The teacher sets tasks and the students go into group mode almost without hesitation and without any teacher prompting.

The students, in discussing their methods, promote each others statements showing a very collaborative and supportive environment.

**Week 12:**

Quite a pleasant collaborative atmosphere is evident with all groups working well together on the set tasks. The teacher interacts with the groups as they work through the questions.

The groups worked quite well (feverish in fact) as a time limit was placed on the completion of the exercise.

The teacher emphasised the importance of working in groups to ensure the concepts are understood so they can still do it when they are working alone that is proximal to actual.

**Week 13:**

The difficulties the students were having cannot be addressed individually (time) and cannot be gone over slowly enough en-mass (time) for all to 'get it'. Therefore we need groups.

All groups are working very well together developing and checking solutions.

Most of the students seemed to be very actively engaged in the groups during the group work time in this lesson.

The teacher quizzes the students on their knowledge and understanding of the current topic gauging their confidence and ability by surveying their responses.

The teacher asks the students questions and uses the responses to build up the examples used to explain the activities being reviewed.

The teacher focuses on groups and asks each a question to help develop the classes solutions to the activity problems.

The teacher uses student responses to build up a series of examples to demonstrate the new concepts and further ideas.

The students worked very well in their groups, quietly doing the activities.

The teacher bridges new ideas from that which the students can do into the next type of problem so they can go on to these. Thus the teacher is building PROXIMAL pathways!!

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5.1.6  

**The environment - group size and effect / layout.**

**Week 11:**

The students seem very accepting of the work set up although they queried regrouping but the teacher explained that this would not happen until the end of the term. When using a variety of equipment the students are moving all over the room and they seem to be working very well when in their groups.
5.1.7 Student support and criticism of each other and the teacher.

Week 11:
The students discuss their methods, promote each others statements, put forward their points of view, discuss those of others, attempt to illustrate the meanings of new terms, support or correct each other as required and generally show a very collaborative and supportive environment.
The students who disagree with the classes majority answer are given the chance to debate the result and put forward their view. The subsequent class discussion / debate usually clarifies things for them.

Week 12:
The students volunteer answers as each activity is discussed and the class makes comment whenever disagreement or confirmation is required. Each group is active in the class discussion of some solutions with support or correction of each other as required. Not everyone agrees with their group or with the class.

5.1.8 Questioning - group focus.

Week 11:
When the class shared a misconception the teacher made some notes alongside a student's solution to illustrate it as it had not been directly referred to. A 'wave of change' moved across the class as the students saw the problem and altered their answers. It is hoped that teacher demonstrations and class discussion of solutions, which come from the students, helps to clarify and eliminate misconceptions.

5.2 Video report - week 12

Video commences with the teacher preparing materials at the front of the class and the students settling into their groups and chatting.

Group 6 - some social chit chat.
Group 4 - Yvonne is drawing or designing something and the others are watching and discussing what she is doing.
Group 3 - Some chatting, some organising their books.
Group 5 - some social chit chat.
Groups 2 and 1 - out of 'shot'.

The teacher greets the class, introduces the video camera operator (a research colleague) and outlines the tasks to be worked on during the lesson.
The students are watching the teacher as the day is explained and begin finding the pages required in their text.

The teacher writes page numbers on the board then glances around the front of the room to check if the students are ready and can find the work.

The teacher places questions on the board. These are designed to test, in groups, the students recall of the work addressed in the previous lesson. The teacher directs the students to complete the task. The students are all focused on the board answering the questions. One student (Penny) queries the possibilities and the teacher makes a comment, then refers her to her group. As the students finish they begin to discuss their solutions within their groups.

The teacher, having listened to some student comments, decides to review, by way of discussion, the ideas from yesterday. To the teacher's question, four or so students volunteer an answer and one student's answer (Denise) is developed by the teacher. The students are attending to the discussion. Then another point is contributed by a student (Penny) and the teacher develops this idea also.

The students are not always looking at the teacher but they can be listening to him (e.g. Denise).

More students (Kerry) contribute suggestions and although these are not the one the teacher is seeking each is used positively to support the developed concepts. When the required piece of information is given, (Yvonne is asked for her idea and it is the one the teacher wanted), the teacher notes and comments on it then goes straight on to the next stage without checking for any other ideas which the students may have had to offer.

The teacher then goes through a set of exercises from yesterday asking particular students (e.g. Betty) for answers. These are then explored for alternatives (Penny) and the teacher comments on the need for only one version which the class vocally agrees with. This was not clear to the students as evidenced by the fact that later they were still confused about how many ways angles could be named.

The teacher moves on to check the questions on the blackboard and comments that whoever answers is assumed to be doing so as the representative of their group. The first answer is given (Louise) and the teacher checks with the class as to who agrees with it and what is an alternative. The rest of the questions are answered by teacher selected volunteers (Faye and Robyn).
The teacher makes an incidental comment which is incorrect and the students correct it. To get to the intended meaning the teacher restates the comment using a different approach. Many hands go up to agree with the given answer and then its alternative and one student (Penny) puts her hand up twice. The teacher asks why would she have done this and the other students give her a reason. The teacher places the conflict back with the student (Penny) by asking didn’t she just agree that the two answers were in fact the same.

Other students make additional comments indicating that they are also confused and so the teacher puts it to the class to make a decision. How many times do you have to write an angles name down when you are asked to name an angle? The class says once! The teacher asks does it matter which way you write it? The class says no! The teacher agrees with the class consensus and summarises the two statements. The teacher then asks do you have to write it down both ways? The class decides you don’t, one way is sufficient.

One student (Penny) then queries the answers to some homework and the teacher, who doesn’t know the answers (ha! ha!), asks her to explain. The class is then invited to follow her explanation by finding the question in their text. The student (Penny) gives a name with four letters. The teacher asks her how many letters are needed and she says three. The teacher demonstrates what she has done and corrects this with an explanation to show the class the preferred way of naming angles.

During this session; - the teacher is fairly animated, moving around the front of the room a fair bit and; - the students are mainly teacher focused, as well as attending to whoever is talking and noting things in their texts as required.

The video focuses on Penny’s text.

The teacher moves on to angle size and intends to build on some student comments from the previous lesson which were not noted then. The teacher asks the students for suggestions. Many hands go up in response.

Vicky volunteers obtuse. The teacher asks how it is spelt. Trudy spells it for the teacher. The teacher asks what does it mean. Gwen defines it.

The students are all attending to the teacher focused discussion.

Narissa volunteers right. Again the teacher asks what does this mean and Narissa defines it. Again Trudy spells it for the teacher. The teacher comments that she (Trudy) must be the class spelling champ.

Amanda volunteers acute. The teacher looks across to Trudy. The class laughs. Trudy spells it then Amanda defines it.
Stacey volunteers perpendicular. Mary asks what does that mean. Trudy says she can't spell that one. The teacher asks Stacey to answer the lady's (Mary's) question. Stacey defines it and the class discusses her definition and disputes aspects of it. The teacher comments on what is said, and gives examples using walls, floors and so on. Denise volunteers a 180° angle. The teacher asks what is it called and notes several suggestions.
The students are attending to the discussion and making notes in their texts.
The teacher draws a 180° angle and extracts the term straight.
Penny volunteers a 360° angle. The students and the teacher define this as a circle or one revolution.
The teacher uses the slang terms 'chuck a 360 or chuck a 180' to familiarise or demonstrate these angle terms. One student (Mary) makes a comment which the teacher acknowledges with a gesture.

The teacher reviews the results so far and then asks what about angles between 180° and 360°? A couple of students express uncertainty as to what is being described so the teacher draws an example of a reflex angle. Some students are quietly discussing the question within their groups (Group 3). One student (Trudy) asks how you can measure that? The teacher stops and looks concerned and agrees with the question, 'hmm, yes, how could you measure that?' Class discussion occurs on this issue then Betty explains how. Not everyone hears and so the teacher asks Betty to restate her explanation. The teacher extracts the term reflex with the help of an analogy to a doctor tapping on knee caps.

The teacher outlines the next steps and asks the students to work in their groups checking over the answers to some of yesterday's questions.
All groups, in camera, appear to go into group mode and begin discussing the questions.

VIDEO FADES and SHIFTS FROM BACK TO FRONT OF ROOM.
Recommencing.

All groups, all students, are checking off their answers as they are given by various students throughout the room. The teacher often restates an answer so all here it clearly. When it is Group 1's turn they get a bit muddled. They do not seem to be working together on this. The class reacts asking for the answers to be repeated and we finally get them all from Group 1. Group 6 also have to repeat their answers.

The teacher then begins the computer activities with the computer at the front of the room, explaining what is to be done and obtaining the assistance of one student (Emma) in running the program. [Pity for Emma, who doesn't like Maths, that the program played up!]. Much
confusion reigned for the operators, (Emma and the teacher), as to the operation of the program but the class did their part well although they were not very accurate.
The video is focused on the computer screen.
The teacher resorts to using a pen to mark the angles. The students are accurate on angles less than 45° but not so good on angles above 45° (on this program which draws angles from 0° to 90°).
Most students are nearly always focused on the computer activity.
The teacher drew an example on the board to illustrate how the computer was drawing the angles differently but the measuring was the same and the students explained how to compensate for the differences. The teacher was quite emotive and expressive when celebrating good student results. The class was also happy when successful as well as self critical when answers are a bit off.

The teacher moved to the other computer at the back of the room and another student, (Betty - self appointed), assisted. The class swung around in their chairs to view the computer. After one example, which the students were able to do easily, the teacher commented that he was not needed any more and left the students to run the activity themselves. The students were very vocal when some called stop early. Touchy! The teacher explained what to look for. The students got a good result and the teacher commented and congratulated them on that success. The next question was very poorly done and some of the students launched into their own exposition to explain to the others where they went wrong. Peer teaching in full flight!!
The students kept doing the exercises on the computer, expressing satisfaction or disappointment with each result.
All the students were very focused on the computer work.
The teacher stops the activity on a very successful student result and swings back to the first computer activity then wraps up that session.

The class moves on to review the text work which was related to the activities which had been covered so far. The students turn to their desks and followed through in their books marking the relevant exercises to be worked on as the pages are read through. A student asks about the use of Proliners versus protractors for drawing perpendicular and parallel lines so the teacher demonstrates this on the board.

VIDEO FADES and SHIFTS FROM FRONT TO BACK OF ROOM.
Recommencing.

The teacher outlines the exercises for the students to do and encourages them to practice the drawing skills they have seen.
The students begin their group work.

Video observations:

Group 6 - slow to begin work - closest to video camera and may be a bit video conscious.
Group 5 - getting on with the work, with some discussion as they start.
Group 2 - mostly individual work, maybe some discussion.
Group 3 - mostly sorting things out individually then some discussion.
Group 1 - getting on with the work, with some discussion of the questions as they go.
Group 4 - some discussion as they begin their work. Mary questions Louise's answers.
Louise points out the correct procedure for the exercise.
Group 2 - working individually.
Group 3 - working individually - some discussion.
Group 1 - discussing - still discussing, working and helping each other for most of the remainder of the lesson. Towards the end they seem to be working individually. Slow to pack up as they note down some homework and/or finish off an exercise.
Group 5 - working individually - now discussing - now working individually - some discussion leads to a question of the teacher by Penny. The teacher discusses her question with her.
The group discusses briefly what was said by the teacher after the teacher leaves then go back to working individually, then another brief exchange, then further discussion.
Group 4 - discussing then working individually, then discussing, then hands go up to ask the teacher a question. The teacher clears up their query quickly and they go on with the exercises discussing a bit then working individually. A bit more discussion but working well through to the bell. Very quick to pack up especially Mary and Yvonne (boarders - and lunch is next!).
Group 6 - individually working, then discussing a bit and comparing answers (Stacey and Vicky). The teacher assists Vicky in improving her measuring techniques as the others continue to work individually. Quick (Vicky) to pack up.

The teacher moves around the room during the group work session correcting the text and assisting the students as they require or where the teacher sees a need (e.g. Vicky - Group 6).

BELL - lesson ends:
The teacher outlines the homework required.
VIDEO FADES OUT
5.3 Observer report - week 13

Observation Session #2: this is a transcription of the observers fieldnotes.

N.B. [] indicates added comments made by the teacher and approved by the observer.

Students enter, get files out, some students check their homework with others in their group.

Lesson started: 11.40 am.
Students work on completing homework.
Listen to the teacher.
Go through answers on board - students interrupt if an answer is wrong.
Teacher works with students orally and on board explaining the algebra content of this lesson and then practising examples.
Students do three on their own.

12.00

Observations made at a distance:

Group 5 - Penny asks Narissa for help, then Narissa helps Robyn, Narissa then does her own work while Penny and Robyn discuss the method, Narissa then goes through and tells the others how to do them.

Group 4 - Mary goes to the teacher and asks for help. Betty [just visiting for the day as the other Group 1 members are absent], Yvonne and Louise work on their own. Betty asks Mary about bracket positioning after Mary comes back from the teacher.

Group 3 - Isobel asks Hillary for help and they check answers, Gwen and Faye work on their own.

Group 2 - Denise, Amanda and Emma all check answers once they have finished. Emma explains the method to Amanda.

12.09 pm.

Listen to the teacher again, work on the board, go through questions that caused problems.
12.15 pm.

The Learning Centre support teacher arrived and checked students work, helped others.

Group 3 - Gwen helped [was helped by] Faye.

Group 6 - Vicky has hand up for teacher help.

Most students seem to be working in groups but they do need help (from the teacher, or the Learning Centre support teacher or other group members). Most seem willing to have a go and then check their results and method. Plenty of discussion in groups as students compare results and methods. They need reassurance that what they are doing is on the right track and then they are happy to continue with this (new?) work. [It is new].

12.23 pm.

Stop and check work.

12.25 pm. Bell went.

Reminder about completion of exercise and assignment.
Went through one final answer as an example.
Students leave.

5.4 MONTHLY REVIEW #5: May / June - Weeks 14 to 17 (inc)

The next section presents highlights from the observational data collected during weeks 14, 15, 16, and 17 of the implementation, Month 5. The data is delineated into the categories described in Table 1 in Chapter 3 and is similar in structure to Month 1. Within each category the data is presented in chronological order from week 14 to week 17. The category Group Work ethic / process is further divided into additional criteria as discussed earlier. Following the observational data, the data arising from specific events is presented. For Month 5 these include the results of the Mid-Term 2 test, the results of the End of Term 2 test and the results of the group-worked End of Term 2 test.
5.4.1  **Group Work ethic / process.**

**Week 14:**
The groups are working well and gaining confidence as the work becomes more familiar to them and they feel more comfortable working together, using ideas from a previous lesson. The teacher emphasised the need for everyone to be teachers, that is we have 22 teachers in the class, highlighting the importance of group help as the students attempt an activity. The students work in their groups on further problems with varying levels of success. The teacher outlined activities to be worked on and the students set about doing these following the usual ethic of some collaboration, some individual work, some more collaboration, and so on.

**Week 15:**
The teacher has to remind the students not to give the answers away when they are all working on the same activity. The students only partly focus on the teacher as they complete their own writing and they vocalise (read aloud) as the teacher writes on the board then groan as they’re told this is a more formal (maths) part of the topic. The students are in a very collaborative, open discussion type mode as they are working quietly and effectively through the activity together in mixed across groups pairs or their normal groups. One set of students are disorganised and even the teacher does not seem able to organise them so a student (Mary) takes over and she sorts things out.

**Week 16:**
When the students are very busy in their groups doing activities they are torn between listening to the teacher, questioning the teacher and trying out the ideas for themselves. The students prepare and work while the teacher talks, watching and carefully following the teacher’s development of the ideas. They are very attentive as the easy to follow explanation is developed. The teacher encourages the students to discuss and develop their ideas in their groups often by implying that group work could make a big task more manageable or by telling one student to check something with her group to encourage the other groups to start checking through their work. The teacher sets the students into group mode to discuss their homework and sets activities for the students to do to try to consolidate the new concepts. The teacher completes a task on the board and several students acclaim their success.

**Week 17:**
All are focused in their work. The teacher directs the students to work in their groups when it is clear that most are no longer asking questions or involved in answering them.
The teacher spends most of the group checking time helping individual students in need of specialised guidance, e.g. Louise, Kerry, Emma and others. Some students sought the help of the teacher to explain difficulties to them but where possible the teacher sent the students back to their groups for help. There is no group work during lessons dedicated to revision for a test as it is usually made up of the teacher outlining topics and the individual students asking questions. The students query test procedures, marking methods and equipment and the teacher discusses all that is allowed.

5.4.2 (a) Discussion / Explanation.

Week 14:
The teacher leads the class through a set of activities explaining new concepts or applying old ones and the discussion gets highly interactive with much debate occurring. Class discussion of problems provokes considerable discourse as some students try to explain and others question the ideas and methods being used. The explanation and discussion of the solutions is extensive and thorough, ensuring that everyone’s queries are answered and that they at least think they understand how to do it.

Week 15:
The class focused on the student solutions as they go up on the board and begin to search for patterns. Some were asked what can they observe and explanations came from Stacey, Isobel, Mary and others developing a complete and near perfect analysis of the first type of function. The students were set a writing activity to summarise the class discussion and discoveries to date. Most seem quite able to do this while a few need further guidance.
The students verbalise agreement with some of the teacher’s comments and notes about patterns and strategies and come up with a very thorough summary of the solutions through this interactive development of the ideas.
The students, from a class perspective, are happy, jovial very attentive and engaged in the class discussion which is not like teacher exposition at all, much more like a balanced student / teacher conversation. Such discussion is lengthy, very interactive, involves nearly all the students all of the time and is dependent to a considerable degree on the students developing their own ideas to formulate the concepts by.

Week 16:
The students are generally discussing their work, the activities and results, working quietly in their groups and interacting frequently through the lesson trying to capture the ideas. They are quick to begin discussion although some were discussing the fact that they did not yet have any information.

Week 17:
The students are listening to the discussion, participating in the discussion or having a discussion of their own within their group.
The discussion forum between the students with questions, concerns and other issues and the teacher and the other students has everyone trying to explain the ideas. The class discusses various examples as they are worked through on the board, a discussion which goes on for quite a while.

The teacher and the students discuss several sections of the course. The discussion is often intense as all sorts of ideas are thrashed out by the whole class.

The teacher opened up the class discussion to those who needed it while others were free to get on with their own revision but some discussion was limited as it led to alternative forms of doing things and time does not permit this in a revision lesson. The discussion moved more into one on one mode (teacher and student) in latter parts of the lesson as some students needed to have specific issues, problems or concerns sorted out and many others were busy with their own revision or look on and extend the ideas with further questions if they so desire.

5.4.3  (b)  Background.

Week 15:
One student (Trudy) brings forward comments about previous experiences by mentioning that she gave a talk (in her German language class) about the activity we are now doing. Gwen notes the common term for a specific maths activity showing her, and others for they agree, past experience. This is addressed and thereby valued by the teacher.

Denise mentions her previous experience about doing this activity in an alternative structure.

The teacher sought more information about her prior knowledge. Denise gives an answer and others ask her how she worked it out. Denise says she did it just then based on the information in the teacher's question but the teacher suspects she has some additional prior experience of the concept. Several others show prior knowledge also.

The students explain their previous experiences with this activity when the teacher asks if they have done this before.

Week 16:

The teacher discussed with the students how the previous lesson had been very teacher centred and how this lesson would be used to find out how much the students knew. The students were able to complete the first steps of the activity.

The teacher emphasises that this is not new work and encourages the students to recall their previous work by discussing an example drawn from a past topic with the aim of trying to connect the concrete building ideas with the recently developed more theoretical ideas thereby highlighting the value of some past work and experience.

Week 17:

The teacher emphasised the need for students to be aware of their background problems as they did this topic and to be willing to ask questions whenever they felt they did not understand something.
A lot of prior knowledge/background issues with regard to the new topic were discussed, (Betty, Cathy, Penny, Vicky, Kerry, Amanda), as it seems the students are keen to discuss any troubles they have had with these ideas in their earlier experiences. Several students admitted (hand up) difficulties when asked to show if they had ever been troubled by this topic.

The teacher spent time discussing the new topic asking the students what they know trying to address all issues and concerns raised from their previous experience. Many of their problems are easily overcome. Some seem disappointed at having the topic to do again and many say they know about the ideas in this topic. The teacher sets the students some activities to complete in their groups. The teacher stopped the class and conducted a whole of class discussion of the ideas which had cropped up from individuals. The teacher builds examples based on student suggestions.

5.4.4 (c) Observations.

Week 14:

Some students are not keeping good quality notes as they are shown methods and examples by the teacher.

When checking through answers the first set of solutions are straight forward but Group 1 (not working well today and haven't checked) get one wrong, Group 4 have to discuss one to verify their answer and Group 2 need to do likewise. Group 5, like Group 1, also get one wrong. Groups 3 and 6 both do very well.

Groups 3, 4 and 5 are all doing good group work in determining the answers. Groups 1, 2 and 6 are working individually until they share and compare their answers. Clarifying was sought by Stacey, Denise and others. Group 2 - Denise may not get it yet but she will. Amanda keeps giving up but is asking questions and may get it yet. Emma seems to be coping but is asking questions. Group 1 - Few questions. Assume they're getting it. Cathy has another method but it is unproven. Group 5 - Lots of discussion and Penny seems to get it. The others don't ask or say anything so it is hard to judge. Group 4 - Mary doesn't look like she is trying. Louise gets some of it but as for the rest? Yvonne didn't let on as to how she was coping. Kerry asked lots of questions. She missed the previous lesson so she needed extra help on how to do some steps. Group 3 - All very busy. Isobel and Faye asked questions but overall it is hard to judge if any of them got it. Group 6 - Wendy is away. Vicky certainly gets it and can even do it mentally. Stacey is struggling and doesn't like to admit she hasn't got it. Trudy seemed left out of it. I don't think she is clear on it.

Group 1 - not working as a group. Group 5 - not working as a group. Group 2 - checking. Emma (2) discussing with Penny (5). Group 6 - some checking and some chatting. Group 3 - lots of helping each other. Group 4 - helping each other but Louise and Kerry came up to the teacher. Group 3 - all much the same ability and strong in helping each other. Group 4 - all fairly weak and confused so lots of discussion occurring but it is not necessarily being
very helpful. Group 1 - more able but less collaborative today (only two present, Cathy is away). Group 2 - trying to help each other but Denise's method is different to that the others are using and Emma's method is a variation of the standard method so collectively they are not much help to each other. Group 6 - Wendy away. The others are chatty and some of this is focused on their maths. Group 5 - slow to get on and check. Probably trying to avoid detailed explanations.

Group 3 - good group work. Group 5 - Narissa and Robyn working together. Group 4 - lots of visits to the teacher then on with the work. Group 6 - lots of visits to the teacher by Stacey and Trudy then on with the work. Group 2 - some helping of each other. Group 1 - Jenny to the teacher for help, Betty working on the activities.

The teacher helped: Hillary and the rest of Group 3, Mary and all of Group 4, all of Group 6, Amanda and Emma and checked on Denise.

Group 3 - With Group 3 the teacher found that the students did have some trouble explaining to each other or believing each others explanations. This group was collaborating well.

Group 4 - With Group 4 the teacher found that the students were very weak and needed a lot of guidance. Much of what they had done was correct but they did not believe in themselves enough to trust their own answers. Some of their mistakes were silly but they are really not empowered to get on and try the work themselves. The teacher spent a lot of time with Group 4 but disappointingly when the teacher left they drifted into a very tardy collection who were not getting on with the business of having a go. The teacher's leaving disempowered them some how. Group 5 - Did not want any teacher assistance when the teacher offered help. Group 1 - also not in need of the teacher's help although one student (Betty) declared that she was bored with it all, as if it was too easy but she had done very little of the suggested work. She probably just couldn't be bothered. She (and others) looked very tired. Group 2 - These students were working well but individually and not on the same tasks. So getting help within the group was difficult. The teacher helped the various Group 2 members as they requested (Amanda and Emma) and the teacher asked Denise if she was clear on the work and helped her with a couple of problems. Group 6 - (Wendy away). Again the biggest single factor affecting the performance of this group seemed to be fatigue. They seemed very tired after the Gym competition. Group 6 were approached by the teacher who then was able to help them with a couple of problems.

Group 1 - lethargic, wounded, over confident. Group 2 - trying hard but not helping each other much, just a little. Group 3 - helping each other. Group 4 - getting help but not willing to try solo. Group 5 - working quietly and slowly. Group 6 - some help each other. They are a bit tired. Some work alone. Group 4 - some working and lots of chat. Group 5 - helping each other and working. Group 3 - lots of mixed helping each other. Group 2 - the teacher helps them and then they are working. Group 6 - some teacher help and then they are working. Group 1 - all working individually. Group 1 seemed tuned out. All the other groups
were fairly well tuned in to the discussion of student queries and each had someone who was asking questions, especially Groups 2, 4, 5 and 6 and to a lesser extent Group 3.

**Week 15:**
The students split into some non-group pairs. Amanda and Denise - 2, Isobel and Faye - 3, Vicky and Stacey - 6, Jenny and Betty - 1, Narissa and Robyn - 5, Penny and Cathy - 5/2, Gwen and Wendy - 3/6, Yvonne and Trudy - 4/6 and Mary and Louise and Hillary - 4/4/3. Kerry and Emma were absent. Gwen explaining to Faye, Narissa explaining to Robyn. Group 4 checking with each other to see if they're doing it alright. Group 4 are very keen to give the solution to the homework exercise and do so. Group 3 are not on task initially. Groups 5 and 6 are slow to get started. The rest are getting on with it, sharing their ideas and results but they do not seem to have a focus. The students ask clarifying questions as they work through the test.

**Week 16:**
The class was split into two halves for an outdoor activity. The positives - Groups 2, 3, half of Group 4 and Betty of Group 1. The negatives - Groups 5, 6, half of Group 4 and Cathy of Group 1. Jenny (Group 1) (the origin) acts as referee and judge and joins the teacher to monitor the activity. The teacher records the results. All the students seem to be well engaged in the outdoor task as it is set up. The activity is carried out. The positives (Betty) and to some extent the negatives (Stacey) are not fully discussing their moves in the first game. Thus it is not a fully shared group activity. The negatives win the first task. In the second task more discussion is evident and the students seek clarification from each other, and Jenny and the teacher, as to the location of points / players and so on. The positives are awarded the second task as they had the longest line. The third activity took longer and produced a lot more within team discussion. Play was defensive. The positives won this encounter despite being blocked once by the negatives. A good game! Leaders; Betty, Isobel, Stacey and followers; Louise, Robyn - from the outdoor activity.

All groups are very busy discussing. Group 1 - some explaining going on. Group 2 - trying to explain to each other. Group 3 - some are working but most are not clear on what to do. Group 4 - not working on task. Group 5 - Penny helping and explaining to Robyn. Group 6 - Good explaining Wendy to Vicky and Stacey. Group 5 (again) - good group work going on. Group 3 (again) - sharing ideas. Group 2 (again) - sharing ideas. Group 1 gave a solution, checked by Group 3, who were the most successful groups in doing the homework. Group 1 - discussing - some (less) discussion - discussing. Group 2 - discussing - some (less) discussion - discussing. Group 3 - lots of discussion - still discussing - still discussing. Group 4 - no discussion - some discussion - still discussing. Group 5 - the school's Learning Centre support teacher helping - school's Learning Centre support teacher still helping -
school’s Learning Centre support teacher still helping. Group 6 - no discussion - some discussion - some discussion.

Week 17:
Many students ask questions: Penny, Mary, Vicky, Isobel, Kerry, Cathy, Emma, Amanda, Denise, Stacey, Trudy, Louise and Faye. Some students do not ask questions: Wendy, Narissa, Robyn, Yvonne, Hillary, Gwen and Betty (Jenny absent). Questions were asked by: Louise, Penny, Trudy, Mary, Stacey, Kerry, Gwen, Hillary, Isobel, Emma and Wendy.
Group 1 - Jenny working, Betty and Cathy discussing questions, then more general discussion and quizzing each other. Group 2 - Emma and Denise discussing, Amanda working on something else, then all discussing. Amanda not doing maths, Denise and Emma reading harder questions. Group 3 - Some discussion of shapes, Gwen working, Isobel (Faye and Hillary watching) comes to the teacher’s desk for information on shapes, comes back to the teacher for more information subsequently, still doing the same. Group 4 - Louise, Yvonne and Kerry are discussing other things, then doing some work, Yvonne effects repairs to her file, Louise and Kerry still doing maths, Yvonne still repairing her file (Mary away). Group 5 - Narissa and Penny working, Robyn watching Penny, Narissa working alone, Penny and Robyn discussing. Group 6 - Split into pairs (Vicky and Stacey, Wendy and Trudy) and helping each other on problems, still doing the same, Stacey asks the teacher a question about algebra in the test. Group 1 - Some discussion and lots of help as they work it all out together. Group 2 - Some discussion and help. Group 3 - A fair bit of discussion - but Hillary is not always able to explain things to the others (she does not know it all) and so after the teacher explained something to Gwen and Isobel they had to go back to the group and explain it for Hillary. Group 4 - Mary and Louise helping each other - Yvonne and Kerry working alone. Group 5 - (Narissa away) - not working together. Group 6 - Trudy and Wendy disagree with some solutions. The teacher sends them back to the group to sort it out and Trudy then helps Wendy to understand. (Trudy just used Stacey to check her solutions against). Group 5 (Penny and Robyn - Narissa absent) did not work well together, most of the other groups did.
The teacher encouraged Group 6 to resolve a dispute about their answers to some of the activities. Group 6 is a good group and they were able to help each other.
All the students (except Robyn, Yvonne and Amanda) interacted with each other or the teacher in asking questions and discussing solutions.
5.5  **Review of Mid-Term 2 test results - week 15.**

The teacher discusses test results with each of the students who (i) failed, (ii) went from fail last time to pass this time or (iii) are possible promotion candidates. A fail is a score below 50%.

Faye - pass to fail; the teacher tried to boost her confidence and told her that he believed she could do much better, as she had in the past, just practice harder.

Robyn - fail to fail; the teacher pointed out the good facets of her work and indicated that the ideas were there but she just needed to concentrate on finishing things off more carefully.

Louise - fail to fail; Louise was not pleased with her result and the teacher showed her how close she was to a pass, pointing out how well she had done parts of some questions. When discussing bearings it was clear Louise had no understanding of the concepts involved.

Gwen - fail to pass; the teacher complimented Gwen on how she had done so well. Gwen referred to some difficult concepts and the teacher showed her how she had done that in the test and congratulated her on her result.

Trudy - fail to pass; the teacher commented how Trudy had impressed with the improvement in her results. The teacher pointed out some areas which need further practice and Trudy agreed.

Mary - fail to pass; The teacher discussed Mary's success but she was not over awed by it. She was already planning how she would work to improve even further. The teacher complimented Mary on her success.

Stacey - top score; as top scorer, the teacher pointed out that continued work at that level could see Stacey moved up into a more able group. The teacher pointed out that this was a goal Stacey could aim for.

Cathy - good score; the teacher highlighted that Cathy was a definite promotion candidate and that she should be very pleased with her results and could aim for promotion if she wished.

Hillary - good score; the teacher pointed out how Hillary's results were very good and that she had a chance to be promoted if she worked very hard on revising.

Betty - good score; the teacher pointed out how excellent her results were and that for her promotion opportunities she needs to focus on the areas she is weakest at. She seemed positive at having a goal.

Jenny - pass to fail; the teacher discussed Jenny's disappointing result and how her behaviour had also turned for the worst recently. She was able to explain what she was doing but when the teacher said he knew she was having trouble in other areas Jenny got a bit emotional. The teacher said all was forgiven and asked Jenny to help herself by asking
for help from others as she needs it. [This was followed up with the school nurse and
boarding house officials and things are 'in hand' in the caring of Jenny].
Denise - disappointing result which she put down to missed work and the teacher suggested
she ask more questions and maybe asked for lunchtime help if she needed to catch up.
Narissa, Penny, Yvonne, Wendy, Isobel(absent), Vicky, Amanda - no comments
Kerry - good, just passed. Lacks confidence and the teacher tried to boost this by pointing
out the good aspects of her work.
Emma - not a pass but better than she thought. Went over some aspects which she seemed
clear on now (with help / guidance) but had not done correctly in the test.

5.6  MONTHLY REVIEW #6: June / July - Weeks 18 to 21 (inc)

The next section presents highlights from the observational data collected during
weeks 18, 19, 20 and 21 of the implementation, Month 6. This is the final month,
with highlights from the study, reported in this thesis. The data is delineated into the
categories described in Table 1 in Chapter 3 and is similar in structure to Month 1.
Within each category the data is presented in chronological order from week 18 to
week 21. The category Group Work etc (group) is further divided into additional
criteria as discussed earlier. Following the observational data, the data arising from
specific events is presented. For Month 6 these include a report on the observation
of the class by a research colleague, a report on the fourth video review of a lesson,
the results of a special group-worked test and a further report on the observation of
the class by a research colleague.

5.6.1  Assessment.

Week 18:
The teacher suggests that not enough homework is being completed and encourages the
students to try to complete as much as they can and to mark their work with red pen when
they check through it in their groups.
The students are quite noisy and chaotic as the end of term tests are distributed and they
compare results, check marks and read through solutions. They go quiet as each privately
examines her own test then, as they compare, the noise resumes. The teacher discusses
various features to do with the test, outlines group scores and comments that Group 4
should be pleased because this is probably the best combined group score they have ever
achieved. The class applauds the highest test scorer (Hillary).
Jenny asks has she improved and the teacher checks her past marks and confirms that she
has.
5.6.2  Group Work ethic/process.

**Week 18:**
All groups are working well on checking their activities and when some strike conflict with their answers the students in those groups immediately go into 'teacher correct' mode and not just 'tell them' mode as they jointly develop their solutions.

**Week 19:**
The class checks each others answers while some students set their ideas out on the board. At other times the students are mainly doing individual work without much teacher direction except to suggest they use the methods they are already using. The many methods used seem to be in conflict and considerable discussion arises among the students and between the teacher and the students. Several students express a variety of methods. Some explaining occurs but the work is mostly individual with some comparison of results. Usually more discussion arises as the students encounter harder problems. Several students exclaim success when the class determines an answer which agrees with their own. The students work quietly, individually and collaboratively on the activities. Each student in the group is doing the work and when they need to, they ask each other about methods, answers, and so on. The teacher quizzes the students about a couple of the answers and then lets the students resume doing the problems in their groups. Every student who wanted to speak was allowed to and they all seemed to want to, or expected to, speak anyway so the teacher would not have been able to inhibit them even if he wanted to. It is automatic now that everyone gets their say. There is no evidence of task sharing although the students do share and compare solutions.

**Week 21:**
The teacher sets the students a group task. All groups work well. Group 1 has trouble resolving a set of questions but Cathy seems to convince and explain to the others, eventually, how to do it. Some tasks are very group focused - others are not.

5.6.3  (a) Discussion/Explanation.

**Week 18:**
Some discussions are very teacher centred and the students just ask the occasional question or made an occasional comment. Other discussions do not in any way resemble lectures and the students are highly involved. The teacher may be involved in one-on-one discussion and the class usually discusses in their groups. At times the groups will quietly discuss their work as they progress through the activities checking over their solutions whereas, on other occasions, the students can be very vocal, demonstrative and active during their discussion of the processes. Students who have completed their work show it to the teacher and are sent to their groups to check through the answers. The students call out the answers, at the teacher's prompting, as they go through exercises or work through some examples. The teacher encourages the students to use methods which are right and which
work for them no matter how simple. The teacher sets activities for the students to do and
suggests that group work might be helpful.
Several students offer advice, ideas, methods and so on to the other students (chat across
the room) so the teacher is not the only teacher as several others are teaching at the same
time and at the same level, that is to the class or to the questioning student. The teacher
emphasised to the students that they should always use simple methods to help them see
how to do such questions. [e.g. the number line which is helping students work proximally].
The teacher explains the activities, gives an overview of what is required or gives examples
of the concepts, perhaps using the board, and then sets the students to the tasks. The
teacher surveyed the groups regarding their descriptions of the techniques or processes
being studied. One concept, which has not yet been addressed in this course, causes
concern for several students and continues to do so even after the teacher discusses it with
the whole class. The concept (volume) is beyond the student's experience (actual
developmental level) and the teacher's explanation fails to bridge the gap for most of the
students. Penny and Kerry give very good explanations on the matter.
The students were a bit confused when subtracting from a negative so the teacher did an
actual example on a number line and several students were heard to say - 'OH!' The
teacher emphasised to those students that they should always use such a line to help them
see how to do such questions. [The line is helping these students work proximally].

Week 19:

The students can be heard discussing their work and asking questions such as 'how did you
get that answer?' or 'how did you do that?', so lots of seeking and asking is occurring. Are
these students getting answers? [the next day the students were unable to answer this
question - so I think this indicates that they were 'satisfied'].
When a long delay to the start of the lesson occurs the students self start and are working in
their groups checking through homework exercises helping and checking each other, a
function of groups. Betty points out that the text has incorrect answers and the teacher
suggests that the students check their results within their groups, that is with each other.
The students who query the procedures of the test are told to work out the details within their
own groups. The teacher sets the students tasks to do in groups and he reminds them to
negotiate the answers to the activities within their groups.
There is considerable duplication among some groups when only one set of answers per
group is required. The teacher makes some suggestions but several students comment that
they are already doing that. Several students give solutions when a set of problems is gone
over. The teacher asked the students if they recalled asking their group for help yesterday
and if they could, did they get help? The students replied that they could not recall asking so
the matter was dropped.

As a student's (Emma's) method is explained to the class many students interact in the
discussion. The class resolves that the method works and many exclaim that now they can
see what to do while others are confused by the activity and ask further clarifying questions. The activity resulted in mainly individual efforts but some helped each other. The students decide to illustrate their ideas on the board and eventually the teacher agrees and develops notes and formulae based entirely on the students' input and knowledge and on their developed concepts.

**Week 20:**

The students commence work on the next activity, in their groups, and are involved in a very interactive discussion to do with the activity. The teacher suggests that he will check answers soon and the groups automatically go into group mode straight away and check their answers. The students provide the solutions as the class and the teacher check the answers to an activity. The solutions and variations are discussed as the class works through them. Sometimes these sessions are very interactive but teacher dominated while at other times the students check through their homework in their groups. The teacher challenges the students to a race to complete the next question. The students are very chatty in and across groups as they aim to get the questions correct. The teacher observes that the activity is different and difficult and decides to demonstrate a couple of steps to the whole class by placing clarifying diagrams on the board and explaining the method. The students query various aspects of the solutions and of the teacher's explanations. Some of the students say that they don't get it. The teacher leads the students through a step by step example then the students do some problems and the answers are checked. Everyone is happier having been through the exercise. The students work briefly on these exercises in their groups. The teacher uses a student's incorrect solution to emphasise the point of her error and encourage all of the students to avoid the same mistake. The teacher leads the students through examples of the next activity. The students work through with the teacher. The teacher has to discuss various points individually, with some of the students, to clarify the ideas for them. The teacher summarises the main concepts for this topic to date.

A challenge question is placed on the board and several students come up and explain to the class how to do it. The teacher asks the students for conclusions to the activity. Several express their opinions and they all agree. The class is therefore informed as to the solutions. The students define a term for use in the context of the activities. The teacher invites students to come forward, illustrate their methods and explain them to the class. Several come forward and the class is fairly happy with the methods outlined. The teacher plays a few games to enhance the students' concept of, as well as thinking and awareness of, probability. Some examples of 'bias' or 'rigging' in an experiment strongly influence the students and many find it difficult to believe that any experiments can be fair.

**Week 21:**

The teacher checks student understanding by questioning the students as the present topic is reviewed. The students provide the solutions as the teacher leads the class through the
questions. The students are quietly checking their work, sitting in their groups answering the teacher as a class. Some activities involve comparing student answers. The teacher encourages the students to discuss in their groups various aspects of the work and their results. The students copy the teacher summary notes as the teacher discusses them. The teacher incorporates students' comments into the summary notes. The students discuss their own progress and results.

Experimental results are available for all of the activities attempted the other day so the students are able to share their results among each other. The students work well in class at sharing results. This occurs for some length of time, in quite an open, social environment. The students call out their results which the teacher collates on the board into a class set. The students calculate class results. The class discusses experimental results and the teacher contrasts the class results with a real world example and with individual student's results.

The teacher uses clear, practical examples to explain probability values and the students are able to correctly determine results based on these. The teacher includes a practical example of selecting objects from a container to determine probability. The students seem able to do this. The students follow through the text as the teacher explains an activity, they watch as different equipment is demonstrated and they listen as the procedures are explained. The students assist in equipment demonstrations to ensure a broad base of familiarity with the pieces. The teacher further demonstrates various probability experiments on the computer. The students are encouraged to estimate results as they barrack for their chosen event. The students conclude that the computer is biased. The teacher compliments the students on their estimates. The students must summarise their observations in writing. The teacher samples the class for observations. The teacher compliments the students on their answers.

5.6.4 (b) Background.

Week 18:
The teacher surveys the class for experience at this work and many respond positively claiming they have had experience with the work (only six or so don't). The teacher has the students check within their groups for experienced people. All have some, but the students' background has different procedures to what is now required. The teacher compromises and incorporates some of the students' background experience into the procedures.

Week 19:
The teacher points out that there is a practical use of this exercise and the students, (including Denise), add further to this with their own experiences. [Student idea, experience, background and opinions are valued and so they speak !]. One student mentions that she didn't do much work on this topic last year (Year 7). Over half of the class indicated and discussed their previous background experiences with the present topic.
Week 20:
The class discussion of the activity illustrated that the students' background knowledge of these issues is very poor. The teacher explains many of the basic principles but not all of these are clear to all of the students due to their lack of experience.

5.6.5
(c) Noise.

Week 18:
The students do their activities in the usual mode - silence as they work out questions on their calculators then quiet discussion as they begin to query the problems and then on to comparing solutions. As the students get further into the work the noise level rises as the discussion increases. Noise levels drop considerably once the discussion phase and the teacher questioning ends or when the work gets more difficult. If the teacher has to explain a difficult or confusing concept then the students will be noisier after the interruption as they discuss what is said. The natural time limit to working in groups occurs between 20 to 30 minutes into the activity as the groups then get very noisy.

Week 19:
They are noisy but productive and are very noisy checking their answers in their groups, probably because they don't take long to check.

Week 20:
The teacher keeps the noisy class in check and makes them pay attention to those giving the solutions.

5.6.6
(d) Observations.

Week 18:
Comparing: Groups 2, 3, 1 and 5. Not comparing; Groups 4 and 6. Group 6 some comparing. Group 4 now some comparing. All groups (2 finished?) comparing well.
Groups marking in red - Groups 6, 2 and Jenny in Group 1 - the teacher has not told them to do this so they are showing some initiative. Some have finished comparing, Group 1, others physically get up and compare distances, Groups 5 and 6, others are still doing the homework, Group 4.
The teacher outlined the work requirements: Group 1 - working individually - still working individually. Group 2 - working individually - still working individually. Group 3 - working individually, some discussion - still working individually, not discussing now. Group 4 - good discussion - still some discussion. Group 5 - working individually - still working individually. Group 6 - working individually - still working individually but some discussion now. All students working on their worksheets - not shared work.
Group work on activities - not really as most are working alone - there is very little discussion of these activities. Later the groups are having conversations while working on the activities and the teacher joins in occasionally. Group 2 not on task.
The teacher checks the groups ideas; Group 1 - they know what to do but they do not express it very clearly (Cathy absent). Group 2 - clear on what to do. Group 3 - some mixed up thoughts but 'clearish'. Group 4 - clear on what to do. Group 5 - Narissa helps Robyn and then they try them. Group 6 - clear on what to do.

Group 5 - Narissa is working in Robyn's proximal 'zone' and seems to be effectively extending Robyn's abilities.

Group 1 - pacing each other and checking question by question (Cathy absent). Group 2 - individual work pace - some cross checking. Group 3 - individual work pace. Group 4 - individual work pace. Group 5 - pacing each other and checking question by question - Narissa still teaching Robyn (proximal development). Group 6 - individual work pace - some discussion between Stacey and Vicky.

Group 1 - still question to question checking. Group 2 - some discussion - not all mathematics. Group 3 - Isobel helping Faye. Group 4 - some discussion. Group 5 - (Narissa absent), Penny and Robyn helping and checking each other. Group 6 - mainly solo working.

The students are working in their groups checking and discussing their homework.

**Week 19:**

Group 1 - organised and quietly doing different questions each, discussing, organising each other as they progress through the questions, showing some excitement at being able to do the questions, Betty checks how to express an answer with the others.

Group 2 - quiet, some argument as to who's doing what, dividing up the questions and doing some each, some discussion of the questions, still doing each one's set of questions as divided up, Denise and Emma discussing questions while Amanda does another one, still setting up more questions to do individually, disputing some answers and who's done some questions.

Group 3 - quite busy, some organisation of who does what, seem to have shared up the questions, Hillary tries to organise the others, questions being shared around and quietly working, individually working until ready to get together and collate answers, Hillary and Isobel seem to be hard at it whereas Faye and Gwen are selectively working doing what they're told and maybe being ignored at times

Group 4 - very chatty to start, some duplication of doing questions, all moved together and very cramped, Yvonne and Kerry in conference, Louise and Mary busy going onto next questions, busy working on questions, Louise asks what is coordinate axes and the teacher explains, Yvonne tries to organise Mary and Louise and keeps everyone on task.

Group 5 - (Narissa absent) quiet, busy, doing all of it each!, no organisation, allergic to tests, still appear to be working individually, discussing answers, Penny tries to disturb Cathy behind, Robyn tries to explain something to an unreceptive Penny, Penny remembers she has to go early.
Group 6 - very chatty, working through it question by question as a team, noisiest of the groups, sharing out questions, Trudy not working as hard but checking others answers and avoids work by saying she can't do the next question.
Some evidence (not much) of learning within the context of doing the test.
Groups 1 and 5 working individually. Groups 2, 3, 4 and 6 helping each other.
Groups 1, 2 and 6 - chatting. Groups 3, 4 and 5 - checking. Betty (Group 1) and Amanda (Group 2) discussing.

**Week 20:**
Groups working on activities - Groups 1 and 3 discussing. Group 5 chatting although they work when the teacher passes by. Group 4 - Yvonne and Kerry are working, Louise and Mary are asking for help. Group 2 - working individually, Emma comes to the teacher for help. Group 1 moves on to the next activity after the teacher notices that they've finished the present work.

Observations of groups during the group-worked test:
Discussing work - 1, 2, 5, 6 - 2, 4 - 2, 4, 5 - 1, 2, 6 - 1, 4, 5, 6 - 3, 2 - 2, 3, 4 - 2, 3, 4, 5.
Working (solo) - 3, 4 - 1, 3, 5, 6 - 1, 3, 6 - 3, 4, 5 - 2, 3 - 1, 5, 6 - 1, 5, 6 - 1, 6.
Discussing work - 3, 4, 5 - 2, 5, 6 - 4, 5, 6 - 2, 3, 4, 5, 6 - 1, 4, 6 - 1, 2, 4, 5, 6 - 2, 3, 4, 5.
Working (solo) - 1, 2, 6 - 1, 3, 4 - 1, 2, 3 - 1 - 2, 3, 5 - 3 - 1, 6.
Discussing work - 1, 2, 3, 4, 5, 6 - 3, 5, 6, 2, 3, 4, 5, 6 - 2, 3, 4, 6 - 2, 3, 4 - 3, 6.
Working (solo) - 1, 2, 4 - 1 - 1, 5 - 1, 3 - 1, 5, 6 - 1, 2, 4, 5.
Observations - the following reflect the main form of collaborative work each group appeared to be using during the group-worked test.
Groups 1 / 3 / 5 - mostly doing the questions individually then comparing answers. Group 2 - working out each question collectively. Group 4 - checking through each others work.
Group 6 - duplicating the doing of the questions to check each other. Group 3 - Hillary dominating and other members getting annoyed with her doing so. Hillary almost doing the test solo it seems. Majority view or Hillary's view?
When working on the activity - Faye with Isobel, Hillary with Gwen, Wendy with Trudy, Narissa with Robyn. These are all 'within group' pairings. Narissa with Emma - the only 'out of group' pairing. The rest seemed to be working individually - Amanda, Mary, Stacey, Vicky, Betty, Denise, Kerry, Louise and Cathy - these last three were sitting near each other in some sort of group. Jenny and Yvonne were absent.

**Week 21:**
Group 5 (Narissa and Robyn) doing most?
5.6.7  

Student support and criticism of each other and the teacher.

Week 18:

Student comments that parallel or support the teacher's ideas are acknowledged and praised by the teacher whereas student comments which may not be correct are still acknowledged and examined, and the teacher may be able to say he sees how the student did it thereby supporting that student, while misconceptions are often highlighted to the whole class to exemplify the problems so all can avoid them. Sometimes other students can see what is behind the idea and predict the error or misconception. When the teacher and the students are instructively working through answers the teacher must respond to multiple suggestions, exalting the most correct, acknowledging and praising the nearly correct and building on and redeveloping the incorrect.

The students interact openly in the checking environment, correcting the teacher, correcting each other, contributing answers, providing answers the teacher does not have. They are quick to jump into discussions to correct anyone with an incorrect or alternative solution that doesn't work or when an answer is not given or needs correcting. This produces a constant conversation level to the work rather than a formal discussion. If students suggest correct alternative answers the teacher leaps on these and praises them to encourage these students. The teacher highlights to the class any important points which arise during the discussion, such as a method demonstrated last week by Vicky, to clarify their meanings. The teacher spends a long time talking to individual students (Kerry, Mary, Trudy) before the lesson proper started.

Kerry and Mary advise that they do not have their books and the teacher suggests they write their answers on paper so later they can transfer them to their books and therefore avoid doing them twice. A short time later the teacher pops out of the classroom to photocopy the relevant pages for the students to work from for the day.

During the MCI, Faye asks what if you're neither a Yes or a No and the teacher says make your own mind up, you can't sit on the fence and this is echoed by the Learning Support teacher (present for the first 10 minutes or so of the lesson).

Week 19:

The students are congratulated when they establish that they have the correct solution to difficult problems and the teacher comments that he is glad that some of the students have alternative ways of working these problems out because his way doesn't always work either. They correct their work in their books and when required chipped in and corrected those giving answers (helpfully).

To get their ideas sorted out the students discuss their methods with the teacher who acknowledges them and checks to see how they work. Some get confused with certain problems and these are explained.
The teacher isolates some of the students' ideas and says that they are 'doomed' when harder questions are encountered but one of the 'doomed' methodologists comments that her method was in fact sort of the same. The teacher points out that the students should look after their equipment as several had reported lost books.

**Week 20:**

The teacher compliments the students on their responses to a recent writing task and for what they were able to do for homework rather than be negative about them not doing some things.

The teacher checks out a strange answer and identifies the problem and tells the whole class, so they are all aware of such errors, by describing it up on the board and then, the whole class discusses it and helps to correct it. Sometimes the teacher and the students agreed to disagree about the ideas but agree to agree on the general method as used in class.

The teacher comments that Group 1, best last time, have 1 member absent. The class makes a collective 'Oh!' sound in half hearted sympathy. The teacher and the students discuss absenteees (3 or so) and much concern for their well being is expressed.

The teacher summarises the findings from the homework and asks the class if anyone has worked out the special formula we are looking for. One student gives her formula which is correct and she is exalted by the teacher. The teacher asks other students to explain her rule and several help out and do so as it is discussed and clarified. Several other students confirm the same formula while another gives a third formula but it turns out to be the same as before, only in parts. The teacher extols the virtues of all of these offerings and uses that which was most agreed upon to highlight as the final result.

**Week 21:**

Sometimes the teacher berates those students whose homework is not complete.

5.6.8 **Questioning.**

**Week 18:**

The teacher asks the students questions on a topic to ascertain how much they know. The students respond to the teacher's questions. Most responded positively (Yes!) to the questions indicating they knew what to do. All agree on the first question but disagree on the second but the teacher uses the answers given to resolve the conflict and so the students are able to solve the problem. The teacher pointed out that the review was done because they, the students, had queried the results. If they had not done so we would not have known the results.

The teacher coordinates the discussion of solutions but all answers come from the students. Some students (Mary and Stacey) ask some questions which point out a problem and the teacher addresses the whole class on the problem and advises them of what to look for and
then gives a simpler parallel example. One student (Trudy) calls out an incorrect response and the teacher finishes the question then, in her direction, makes a correcting comment which she acknowledges and agrees with. Stacey, Mary and Trudy comment that they're not sure what is required of them as regards their summary. The teacher's initial reaction is negative because this is an old summary but the teacher mellows while talking and runs through the details required. Several students (Denise, Jenny, Mary, Louise, Robyn, Amanda and Vicky) come up to the teacher's desk during the lesson to discuss a variety of matters. The teacher was asked questions by; Isobel, Kerry, Emma, Vicky, Mary, Betty, Jenny and Yvonne. Jenny checks with the teacher as what she should do when finished.

**Week 19:**
As the teacher explains methods to the students they can interject and question various steps and come to the board to illustrate their interpretations. The students query answers with the teacher, when the groups cannot resolve them, so the teacher discusses their problems then addresses the whole class on the more troublesome questions with the students developing the solutions step by step. The teacher accepts student input into any of the work being addressed. The teacher discusses and describes the requirements for the project. The students ask questions to further clarify their understanding.

**Week 20:**
The class checked through some solutions using the students' answers.
The teacher waits for more hands to go up, threatening to ask someone who has not yet raised their hand. One question lacks a piece of information and a student works out the value so the teacher gets her to explain how she got it to the whole class. This problem is worked through on the board to clarify how it is done.
The teacher explained one of the tasks and asked for solutions that all of the group had agreed on. Several (>8) solutions were given and when checked, one was found to be correct. All of Group 3 had answers. Several students tried to give estimates but many were way off. Vicky, Isobel, Kerry, Trudy, Jenny, and Emma all ask the teacher for help about the activity.

5.6.9 Teacher comments and observations.

**Week 18:**
The teacher makes up little stories, to enhance the students' understanding of the numbers being dealt with, and gives examples using practical situations of the mathematics as used in the real world.
The teacher moves around the room observing the students and the groups working, monitoring their progress, answering questions as required and discussing exercises, problems, methods and other things with various students, either because they ask questions or because the teacher observes and comments on the student's work.
The teacher addresses the class on matters arising from observations of students and groups to discuss often occurring problems or on a matter brought up by a couple of students, to clarify the steps.

**Week 19:**
The teacher defines terms to be used while emphasising specific pronunciation. When most of the students have finished the answers are checked among the class using the students' responses.
The visitors, a university colleague making a video recording, and another university colleague observing, also move around the room monitoring student progress and helping out as required.

**Week 20:**
The teacher asks the class about some further ideas about probability events. The students' ideas are summarised and examples are given to show their use. On being shown a biased event the students pick it quickly as biased. They are getting the idea now.
The teacher has been cutting the students off in various discussions.

**Week 21:**
The teacher makes many comments about the video concerning individual and group behaviours. The teacher goes slowly through a section of the tape explaining various features like group help and camera shyness.
The teacher discusses experimental results and procedures and defines the terms to be use in this topic.

5.6.10 **Tape recorder, video recorder and observer.**

**Week 19:**
The teacher commented on the role model value of the second university colleague who visited our class yesterday.

5.7 **Observer report - week 18**

Observation Session #3: - this is a transcription of the observers fieldnotes.

N.B. [ ] indicates added comments made by the teacher and approved by the observer.

11:40 - lesson starts - teacher talk - revision [? hadn't done multiplying before] lesson on decimals on the board.

11:45 - Students discuss the method of shifting the decimal place.

11:50 - Students do practice exercises and the following observations are made:
Group 1 - Betty and Jenny - (Betty talked most, Jenny agreed) - [Cathy absent].
This work is easy to do. Both like working in groups, you can check answers. Do the work first, then check. Sometimes work in groups in other subjects e.g. in Science but mainly on your own in Social Studies and English. Mathematics is much better because you can talk to each other and help each other. If you need the teacher he is there to ask for help but it has to be a group decision, that is if no one can work out what to do then we ask the teacher.

Group 5 - Robyn and Penny - (equal talkers) - [Narissa absent].
Finding the work pretty easy to do. Both like working in groups because you can talk to each other. Can also help each other to understand the work by explaining it again. Sometimes in English and Social Studies they work in groups but Mathematics is the only subject that does this all of the time. Not allowed to work in groups for tests though! The teacher can be asked for help if we need to.

Group 4 - Yvonne, Mary and Kerry - (Yvonne and Mary talked the most) - [Louise absent].
This work is pretty easy to do. Enjoy working in a group - can talk, discuss answers, help each other. If someone in the group doesn't know what to do then you can explain it to them (except for tests). It makes it easier to work in groups and we get more work done. We can ask the teacher for help but usually we ask each other first and then if no one can do it we ask the teacher. In Social Studies we occasionally work in groups but Mathematics is the only one we always do.

Group 2 - Amanda, Denise and Emma - (not very talkative, Denise talked the most, straight answers, Yes - No types) - this group seems to require more teacher help. [This is not often the case. They were just asking more questions than usual on this occasion]. Some of the work is hard to do, the first two pages were easy. Like working in groups, can help each other. Don't do group work much in other subjects, sometimes in Social Studies for research.

Group 6 - Trudy, Stacey, Vicky and Wendy - (Trudy talked, Stacey and Vicky added a comment). Enjoy working in groups, can talk. If we don't understand something we ask everyone in the group first and then the teacher. We don't work in groups in other subjects, occasionally in English or Social Studies. We get all our work done eventually, sometimes you can be a bit slack and then the next minute you have your head down working again.
5.8 Video report - week 19

Note: * indicates an observation which highlights evidence of helping and thus of students working across their proximal 'zones'.

Video commences with groups in discussion mode.

The teacher is with Group 2 helping Amanda, Denise is listening to Amanda and the teacher, Emma is working on her text activities.
Group 4 - all individually working on the activity.
Group 3 - some discussion of their work is going on.
Group 6 - some discussion of their work is occurring. The teacher moves over to check on their progress and discuss things with them.
Group 4 - the teacher moves across to check on the progress of this group. They are working individually. Kerry asks the teacher a question and he responds then she goes back to work.
Group 2 - now individually working.
Group 3 - mostly working individually, * Faye is asking a question of Hillary and they discuss the issue.
Group 1 - the teacher drifts by and checks their progress. They seem to be finished. Jenny checks an answer with the other students.
Group 5 - being assisted / monitored by Dr. F.

The teacher stops the class, greets the students and explains that the correct answers for the activities they are presently working on will be available tomorrow. The books answers are not always correct.
Most of the students are still head down (Louise, Kerry, Yvonne, Isobel and Hillary), some are head up (Faye, Gwen and Denise), as they listen to the teacher, who goes on regardless.
The teacher introduces the two research colleagues Dr. M and Dr. F and asks the students to be free and open in their responses to Dr. F's inquiries.

The teacher surveys the class to see who has finished, sets an additional exercise for the students to do and asks the students to get on with the work they were doing or the new task.
Emma comes up to the teacher and asks a question about the new task.

Group 4 - still working individually.
Group 3 - resumes working individually. * Hillary and Isobel discuss a point.
Group 6 - * Trudy, Stacey and Wendy are discussing a problem, Vicky is working on her own.

The video fades out and resumes focused on Group 4:

Group 2 - * Amanda asking Denise a question and getting an explanation.
Group 3 - working individually.
Group 4 - working individually. Zoom in on Mary’s page. She is counting squares to determine the area. Louise checks on Mary’s progress. Louise comments that Mary is doing the activity differently to her. All working individually. Louise announces she has finished. Mary and Kerry indicate where they are up to. Mary looks to Yvonne to see how she is going. Louise calculates an answer.
Group 2 - Amanda and Denise check with Emma to see where she is up to then check each others answers.
Group 3 - working individually. Faye and Gwen are off task. Gwen goes back to work. Hillary and Isobel are working. Faye is still off task. Now Faye is on task. Gwen looks across to see what Isobel is up to.
Group 6 - all working individually. Stacey notices the camera is focused on them. Wendy asks Stacey about a question. * Trudy and Stacey help Wendy to work out the answer. Vicky keeps working on her own.
Group 3 - all still working individually. Faye barely on task.
Group 2 - working individually but occasionally checking answers. Denise gets up and moves around next to Amanda to show her what she has done and compare answers. Amanda and Denise discuss their solutions.
Group 1 - working individually.
Group 3 - working individually. Isobel discusses an answer with Gwen. The teacher checks Gwen’s work and they discuss a couple of points.

Group 4 - the teacher discusses work with Louise. Mary and Yvonne also add comments. Kerry works on alone. The teacher helps Louise check through her work after she asked him to. The teacher and Louise discuss how she dealt with the problem. Mary also asks if her method is acceptable and the teacher comments that this is interesting as both students have used different methods on the same problem. Yvonne chips in and gives her result. Yvonne had used the same method as Louise. Louise, Mary and the teacher question Yvonne and her result thereby involving her in their discussion. The teacher never says who is correct or not. The teacher suggests each of the students re-calculates the problem using the other method. * Mary asks how the other method works and the teacher explains using Louise’s work as the example. Mary queries the idea further and the teacher shows her a bit
of the method in her book. Mary says she has sort of done that already and explains her idea to the teacher who agrees with her.

The teacher suggests that the students leave that activity, accepting of the different answers and the different methods and further suggest that the group might like to try the next activity together but using their own methods to see how they compare. Yvonne and Louise are already busy re-doing the activity.

The video fades out and resumes focused on Group 4:

The teacher and Group 4 are again discussing the first activity. They have multiple answers for the activity. Mary comments that Penny from Group 5 also got a particular answer.

Kerry looks puzzled at this. Yvonne and Mary chat with Penny then the teacher suggests (twice) that they work together on the next activity to compare their methods. Yvonne, Mary and Kerry all begin to work on the next activity but Louise hesitates and then leans across and asks Yvonne a question.

Group 3 - working individually.
Group 2 - working individually.
Group 1 - working individually.

The video fades out and resumes focused on Group 3:

Group 3 - Gwen asks Hillary a question to which Hillary responds. Close up of group 3 member's texts. All working individually. Faye asks Gwen about an answer which they then discuss. Back to working individually.

Group 1 - comparing answers, working individually.
Group 2 - Emma working alone. * Denise helping Amanda with some problems.
Group 5 - Dr. F is in discussion with this group as they (Narissa absent) work through the activity.
Group 6 - Vicky and Wendy are working individually. Trudy and Stacey are in discussion, Vicky is now listening in.

Group 4 - working individually. Mary gets up and comes around to Kerry to discuss some point. Working individually again. The teacher stops as he walks by to check on their progress. Firstly Kerry and then Louise discuss their solutions with the teacher. Mary and Yvonne discuss solutions and then ask Kerry also. The teacher moves on to discuss the activity with Yvonne and Mary. The teacher discusses with Mary the use of the method as applied in the real world. Yvonne, Louise and Kerry get on with the activity. Louise asks which method is the easiest.
Video fades out and resumes focused on Group 4:

The teacher is helping and explaining something to Louise with Mary listening in. Yvonne and Kerry are working individually. * In showing Louise what to do she exclaims 'Oh!' as if to suggest that she now gets the idea. Mary asks a question which the teacher answers then asks if she was correct and Louise tells her she was and the teacher confirms this. Yvonne and Kerry discuss solutions and Yvonne leans over to check what Kerry is doing. Later Kerry and Yvonne are again discussing.

Group 5 - working individually. Penny checks work with Robyn who is resting. Now Penny and Robyn are working through the questions together.

Group 1 - working individually until the teacher is called over by Betty. The teacher and Betty discuss something. The others are working alone.

Group 3 - working individually.

Group 2 - Dr. F is discussing the work with Emma. Denise and Amanda are listening.

* Amanda gets up and goes around next to Emma to explain things to her. Dr. F asks Emma questions and with the help of Amanda she answers them. Denise continues to work on her tasks occasionally giving an answer to the others.

Group 6 - Trudy and Stacey are comparing answers, Wendy and Vicky are working individually.

Camera angle changes:

Group 1 - working individually.

Group 2 - Amanda is helping Emma as they talk with Dr. F. Denise is working alone.

Group 3 - Isobel and Hillary are discussing. Faye and Gwen are working individually.

Group 4 - Mary and Louise are discussing. Yvonne and Kerry are working individually.

Group 6 - The teacher moves over to talk with Trudy and Stacey. Vicky and Wendy are working individually.

Group 4 - Louise asks Kerry about an answer.

The teacher stops the class and discusses a particular question which it is decided can have an estimated or approximated answer.

Many students continue working when the teacher says stop where you are and goes on to explain some issues.
The teacher asks the students 'who has the biggest (pause !) hand?' and shows the students a hand. The pause increases the number of students attending directly to the teacher. In view one can see Vicky and Kerry snap around and look at the teacher then.

Every student participates in finding their groups biggest hand. Every group is busily and noisily determining the result. The teacher asks who has the biggest hands. Group 4 suggests that they have two the same but the teacher says someone must have a bigger hand.
To prove these results the teacher asks all the students to trace their hands on grid paper and to count the area. The teacher demonstrates how to draw the hand. The students get out their grid paper.

* Group 4 - Mary traces her own hand, Yvonne helps Kerry trace hers and Kerry helps Louise trace hers. Mary and Yvonne compare tracings. Mary remarks that her hand is very wide and the teacher checks that her hand was closed when traced. It was and the teacher says so. All the students are involved in counting their areas. Louise shows Kerry her hand drawing. All working individually now.
Group 3 - Gwen checks a step with Faye. All working individually on the task. Faye compares drawings with Isobel and Hillary. All are working individually now.
Group 6 - Stacey discusses hand shape with Trudy as they commence tracing. Wendy and Vicky are busy working. Everyone compares tracings.
Group 2 - Denise comes up to the teacher at the beginning of the task to ask for more grid paper. Amanda and Emma are discussing the task. Dr. F compares her hand with Amanda's. Each student is doing the task. The students continue to discuss the activity as they do it. Now working individually.
Group 1 - All working on the activity. Tracing their own hands and indirectly checking, visually, no discussion, with each other. Some discussion now between Betty and Cathy.
Group 5 - Working on their tracing. Camera focuses on them. Penny and Robyn are discussing their work. Very embarrassed (Narissa) at having the camera focused on them (her). Zoom in on Penny's page. She doesn't seem to be doing much. Quietly working on with the activity.

The video changes position:

The class is still working on the area of their hand problem. The teacher advises the students to take the little extra bits off some parts and put them anywhere else they need a piece about the same size.
All the groups are scanned by the video.
All students are working individually, counting squares.
The teacher is discussing how these techniques are applied in the real world, in hospitals. Some students (Group 2) interact with the teacher in conversation and comment about the applications mentioned.

Group 5 - Penny and Robyn are discussing the work. Kerry (Group 4) asks the teacher a question which is easily answered with no need for discussion.

The teacher advises the students that he intends to collect their work. The teacher moves around the room checking on student progress.

The video changes position:

Group 4 - close up of Mary counting her squares. Group 2 - all working individually on the activity. The teacher is discussing the work with Denise and Emma. Group 3 - all working individually on the activity. Group 6 - Dr. F discussing the work with Trudy and Stacey. Group 4 - Louise and Mary make comments about their results.

Video pause, then resumes:

* The teacher is assisting Denise and Kerry in making a comparison of their hand sizes. Dr. F is discussing results with Yvonne and Mary. Some Group 3 and Group 6 students (Faye, Wendy and Vicky) are watching Denise and Kerry. Faye discusses results across with someone in Group 6.
* Good close up of Kerry and Denise comparing hands. Group 6 are still working individually as is Group 3 except Faye who is looking around and asking others what their results were. Denise moves over to Group 1 to compare hands with Jenny. Group 4 all discussing, with Dr. F, their results. Jenny and Denise compare hands and discuss their results and those of Kerry.

The class is in general discussion of the results with many of the students' attention drifting all around the room. Denise is still walking around.

Group 4, with Dr. F, is still comparing hands and results and Mary makes an excellent comment to Yvonne namely 'maybe your hand is wider'.
The teacher addresses to the class Denise's suggestion that the results depend upon which hand you use as everyone has one side of their body larger than the other. The teacher asks if anyone agrees or disagrees with that. The whole class begins comparing their own hands and generally discussing the idea.

The teacher gives a couple of demonstrations of different arm lengths and comments about other body parts such as legs and ears. Kerry and Denise both come out to the front to show the teacher how their own hands compare. The students compare ear positions.

Throughout this, Gwen, Hillary and Isabel, of Group 3, just ignore it all and keep working on the calculation of the area of their hands. All the other students in view (Groups 2, 3, 4 and 6) are participating in the discussion although Stacey and Trudy, Group 6, are mainly working on their own.

The teacher shows the students a tracing of Denise's foot which could also have it's area calculated. This promotes discussion of various feet features among some students.

The teacher asks the class the question how would they measure the total surface area of their bodies. This creates quite a lot of open discussion.

The teacher stops the class to address another activity. Eventually all of the students focus on the appropriate page.

The teacher gave several real world examples of the method being examined.

The teacher set various groups the tasks of determining the solutions. The students commenced the task but many asked clarifying questions.

The teacher gave several visual and verbal clues and hints to help the students through the exercise.

The students worked individually and collaboratively in a variety of mixes on this exercise. Lots of discussion ensues both with the teacher, within groups and across groups. The teacher summarises the activity, the bell sounds to end the lesson and the teacher suggests some additional homework exercises.

Video ends.
5.9 Observer report - week 21

Observation Session #4:  - this is a transcription of the observers fieldnotes.

N.B. [ ] indicates added comments made by the teacher and approved by the observer.

11:40 - lesson starts.

The teacher explains the activities to be done, talks about work to be collected.
The teacher demonstrates numerous dice (4, 6, 8, 10, 12 and 20 sided) and other chance-tossing items (bottle tops, thumb tacks, and the like).

11:50 - the students start the activities.

Observations / Interviews:

Emma and Hillary  - (Emma talked the most)

Maths is the only class where we always do group work.
Sometimes we do role-plays in English, no group work in Science or Social Studies.
If someone can't do a problem then the rest of the group helps them.
We can ask the teacher for help if we need to after that.
We have done coin tossing activities before (primary school).

Wendy and Gwen

Haven't done this work before with dice.
Have done some coin tossing in primary school.
Always work in groups for maths.
Sometimes in Science we work in groups for activities.
If we can't understand something in maths we ask the rest of the group to see if they can help and then ask the teacher if we need to.

Denise and Faye

This work is new to us.
We did coin tossing a couple of days ago but we haven't done any of this sort of work in primary school.
Haven't heard of probability.

Stacey and Isobel

Have done coin tossing the other day but neither have done any work like this before in primary school.
No idea about the term probability.

[N.B. - Mary was absent today].

Vicky and Trudy

Vicky - No work at primary school on coin tossing or probability.
Trudy - Has experience of coin tossing, dice throwing at primary school.
Did lots of experiments, talked about the results, chances of something happening, percentages.
Probability was mentioned but the term was not used often, mainly chance of something happening.

Narissa and Robyn

Have both had some experience in coin tossing and dice throwing activities.
Robyn had no mention of probability.
Narissa couldn't remember discussing the results or mentioning probability or chance.

Cathy and Penny

Very little experience.
Can't remember doing much of this in primary school.
Some discussion of coin tossing but no experiments.
No discussion of probability or chance.

Betty and Jenny

Lots of activities in primary school but very little discussion.
No mention of chance or probability.
Betty used coins, 6 sided dice.
Jenny used coins, 6 sided dice, cones, large cubes.
Amanda and Louise

Nothing like this in primary school.
Louise said she had done a little bit of coin tossing.
(Rushing to finish so answers brief).

Kerry and Yvonne

A little bit of work on coins and dice throwing last year but not very much.
Didn't discuss probability or chance.
(In a hurry to finish activity).

Comments:

All of these answers are susceptible to memory loss.
that is even if they can remember doing the 'exciting' part (the activities) they may not remember the 'boring' parts (discussion and explanation).
APPENDIX 6

EXAMINERS REPORTS and RESPONSES

This appendix contains the three examiners reports and the candidates responses detailing the corrections now incorporated in the thesis.

Each report offers valuable insights into possible avenues of further research along with appropriate cautions regarding the interpretation of the research reported in this study.

6.1 REPORT BY EXAMINER 1

The implementation of a collaborative peer interactive mathematics classroom learning environment.

The thesis examines the literature on collaborative learning environments in classrooms, Vygotskian theories, constructivism and suitable research methods focusing on ethnography and action research. It then describes and evaluates a study of the establishment of a collaborative peer interactive mathematics classroom learning environment, using multiple data sources.

The study is well designed and implemented and the findings are extremely interesting and of enormous value to education generally and to mathematics education in particular. The candidate is to be congratulated on a superb study, providing teachers and researchers with fascinating insights into this way of working. I recognise the limitations of size, but I would like to have seen what happened in the second half of the year. His review of the limitations of his study are very appropriate but what he has produced, just in terms of the classroom learning environment, is to his credit.

The thesis is well presented too. There are few typos indeed, except for too many apostrophes where there shouldn't be, and many absent where they should be.

There are some problems with the thesis however. Some are more substantial than others, but I am sure that this work is worthy of a PhD, after some changes.
1. The literature review has some substantial gaps. The purpose of a review in a PhD is partly to demonstrate a knowledge of the field, but mostly to locate the work in the field and to indicate where it draws on other work and where it charts new waters. My remarks are mostly in relation to the second task, although criticism on the first are also implied. I recognise that it is too late for the candidate to be able to use the insights from the literature to which he has not referred.

There is actually much more work in the mathematics education research community that draws on and develops Vygotskian perspectives, than are mentioned here and if he had kept an eye on the proceedings of the PME conferences, and/or AERA publications he would have noticed this. Bartolini Bussi has done some very important work which develops two aspects of concern to the candidate: mathematical discussion and the need for long term studies.

Boero has also carried out many studies which argue for long term studies in order to see the effects of instruction.

Forman’s work is referred to, but only her 1985 studies. She has continued working since, and her studies of classroom language as the teacher mediates students’ learning are very important and relevant to this thesis.

Van Oers is another Vygotskian researcher whose work is relevant, and Crawford too.

All these researchers work in the field of mathematics education.

More generally what about all the work of Valsiner (only one mention, from 1988) and Van der Veer? Their deep studies of Vygotsky’s ideas are hugely important. For instance, they identify three stages of Vygotsky’s interpretation of the ZPD, during the last 15 months of his life.

Wertsch, too, has several books since the 1985 one mentioned, which have important things to say. The candidate should have been using these ideas

2. The methodology chapter uses work that is quite old, rarely later than 1993 and most from the 1980s or earlier. As a consequence many of the important debates around ethnography, the role of the researcher and action research are not reviewed.

Postmodernism has had much to contribute to educational research methodology and this is completely absent. Now as it happens the methodology and research methods that are used here would not be very different if the candidate had discussed the literature of the last 10 years, but
his perspective on it would have a different orientation which could have enhanced the work.

3. There is quite a muddle around constructivism, social constructivism and Vygotsky's work. Now I know that this is a debate, drawing in writers such as Cobb, Confrey, Steffe and Lerman in mathematics education, and Bruner is on record as saying that you can't put Vygotsky and Piaget together. Every researcher is entitled to her or his opinion. But where there are confusions, they should be sorted out. First, the candidate rightly indicates that Vygotsky's work has a clear role for the teacher: indeed, instruction is absolutely, central to his whole body of work. He also rightly indicates that the role of the teacher is not at all clear in Constructivism. Piaget suggested that the teacher call interfere with children's learning and the radical constructivists had nothing to say about the teacher for many years. In the last 10 years they have gone in one of two directions. Cobb and colleagues have moved towards a social constructivism which incorporates the teacher, still in terms of providing perturbations, but also in terms of establishing classroom and mathematical norms, very important for the thesis. Steffe and colleagues, and also Simon, have stayed with strict von Glasersfeld-inspired ideas and argue that the role of the teacher is to make models of students' mathematical knowledge, since they can never know what children are thinking, and aim to provide activities that stimulate assimilation (Steffe) or accommodation (Simon). Why then does the candidate talk several times of a "constructivist referent of pedagogic practice"? In fact he never shows us what it is, but instead demonstrates extremely effectively what a Vygotskian inspired teacher would do.

Second, the candidate seems to need constructivism to be able to talk about prior learning of students, and their individual development. But isn't that precisely what Vygotsky was interested in when he called his book "Thought and Language"? The former is what the individual brings to any learning situation, the latter comes from culture, and the two are in dialectical relationship. Building on spontaneous concepts (as well as them being 'produced' after the introduction of scientific concepts) is also about prior knowledge. 'Why on earth does the candidate need constructivism for this issue? Again, the concluding chapter doesn't shed any light on this.

Third, on page 94 he says that constructivists "do not believe in the existence of 'reality'". But Vygotskians do, at least as cultural reality if not a real world. So which are you?
Fourth, discourse has quite different purposes for constructivists and Vygotskians. It is nonsense when people say (the candidate doesn't make this mistake) that Piaget was not interested in social interactions: for him they provided the main source of disequilibrium and it's the same for the constructivists today. But for Vygotsky discourse is much more crucial, as it provides the hole development of the individual. Mediation, tool use and signs are all about that. By the way, mediation is NOT the interaction between individual ideas and group ideas, as the candidate says more than once. He does not use mediation at all (a pity) so this misunderstanding is not crucial. But, again, where does he sit with regard to discourse? It makes a difference for his theoretical framework.

Some smaller points

4. Vygotsky's first formulation of the ZPD was about the inadequacy of IQ tests as they ignored what a child was just reaching for, the dynamic element of learning. Assessment, therefore, needs to measure both the zone of actual development and through dynamic assessment (Ferrara) the zone of proximal development. Why didn't the candidate refer to this and try some for his class?

5. On page 122 he says "culture was not a factor in the classroom as only one student was from a fundamentally different culture from the rest of the class". This is a very shallow view of culture - see for example Lerman's plenary paper at PME 1998.

6. I am completely unconvinced by the claim for a classwide ZPD. It actually reads as no more than well-established socio-mathematical norms. We will need some recognition rules for a classwide ZPD if we are to accept and understand what it is, and we do not have them here. I am convinced by the dynamic overlapping multiple zones, so I recommend ditching the classwide ZPD notion - but it's only a recommendation. The alternative is to present a better argument for it, and show how it is more than socio-mathematical norms. It is certainly not something Vygotsky would have understood, so it must be carefully, presented if we are to be convinced.

7. It is quite unnecessary, in the analysis in chapter 4, to continue to quote from the literature almost every time the thesis typeface appears, especially as so
many of the quotes are repeated over and over again. The framework has been developed, we don't need to see it repeated all the time.

As I said above, the study itself, the research methodology, and the insights the thesis provides into establishing, developing and maintaining a collaborative peer interactive mathematics classroom learning environment is quite good enough to merit a PhD.

I require that the candidate change the first two chapters to reflect current literature. I would also suggest that the candidate thinks carefully about the constructivist elements of his theory and perhaps revise some aspects of it, or present better arguments for blending constructivism and his very well argued Vygotskian position.

6.2 RESPONSE TO EXAMINER 1

The candidate wishes to thank Examiner One for his guidance as to how to enhance the thesis and for his comments about the thesis, repeated below, which reflect well on the candidate's study.

Examiner One said:
"The study is well designed and implemented and the findings are extremely interesting and of enormous value to education generally and to mathematics education in particular. The candidate is to be congratulated on a superb study, providing teachers and researchers with fascinating insights into this way of working. His review of the limitations of his study are very appropriate but what he has produced, just in terms of the classroom learning environment, is to his credit". The thesis is well presented too. I am sure that this work is worthy of a PhD, after some changes.

In his summary, Examiner One stated:
"As I said above, the study itself, the research methodology, and the insights the thesis provides into establishing, developing and maintaining a collaborative peer interactive mathematics classroom learning environment is quite good enough to merit a PhD".
6.2.1 Comment on changes required by Examiner One.

**Point 1:**

Examiner One stated: "I require that the candidate change the first two chapters to reflect current literature".

In requiring the candidate to change the first two chapters to reflect current literature, Examiner One specified particular authors and publications. It is clear from these specifications that Examiner One is expressing his personal preferences regarding the fields addressed by the candidate's study. In his review, Examiner One states "every researcher is entitled to his/her opinion". Thus the opinions which the candidate expressed on matters contained within his thesis are opinions he is entitled to express and hence need not necessarily be altered to reflect the opinions of others. Consequently, the suggestions of Examiner One may not reflect the beliefs or interpretations of the candidate which evolved or emerged during the course of his research.

The sources of some of Examiner One's suggestions are quite 'exclusive'. For example, Examiner One refers to proceedings from the Psychology of Mathematics Education (PME) conferences. These are not available in Western Australia although the candidate has sourced some of these proceedings through professional colleagues and the candidate's supervisor. In seeking publications by the authors recommended by Examiner One, the candidate has sourced and searched through the 19 research journals listed in Table 28 overleaf. The listing notes the publication years which the candidate has searched.

The candidate located many articles from these journals and one further article from the two PME conference proceedings he was able to review.

In requesting changes to the candidate's literature chapters Examiner One comments that "There is actually much more work in the in mathematics education research community that draws on and develops Vygotskian perspectives, than are mentioned here". The candidate believes that the evidence contained in the articles reviewed indicates that 'drawing on' and 'developing' are in fact two distinct processes. It is true that many researchers draw on Vygotskian perspectives. In fact, one could say that this seems to have become a 'fashion' of late.
Table 28
Research journals sourced and searched.

<table>
<thead>
<tr>
<th>Journal</th>
<th>Years searched</th>
</tr>
</thead>
<tbody>
<tr>
<td>Review of Research in Education</td>
<td>1997</td>
</tr>
</tbody>
</table>

For example, Bartolini Bussi states that her study "follows the Vygotskian trend, with emphasis on the social construction of knowledge and on semiotic mediation by means of cultural artefacts" (Bartolini Bussi, Boni, Ferri, and Garuti, 1999, p. 67). What is clear from the available readings is that only a minority of these researchers actually develop Vygotsky's ideas any further than has previously been done.

The articles the candidate obtained, authored by the researchers recommended by Examiner One, reflect this trend, of reference to, but not significant development of,
Vygotsky's perspectives. For example, Bartolini Bussi utilises "the theoretical construct of semiotic mediation (Vygotsky, 1978) in an attempt to substantiate its crucial effect on pupils' learning and metalearning" (Bartolini Bussi, 1996, p. 13, italics in original). Bartolini Bussi states that her "theoretical constructs are borrowed from the Vygotskian school and elaborated" (Bartolini Bussi, 1996, p. 11). This is an example of 'drawing on' not 'developing', as the author substantiates an effect rather than designs or develops new processes emerging from Vygotskian perspectives.

It is also interesting to note how Bartolini Bussi utilises a 1978 Vygotskian publication which is known to have flawed and biased translations and interpretations of Vygotsky's works, as I described on page 8 of my thesis: Many authors and translators have "taken significant liberties with Vygotsky's original works" (Simon, 1987, p. 611). In the thesis I also point out that it is the 1987 publication which is the more correct authority on Vygotsky's work (Vygotsky, 1987). Many modern researchers are still promoting these earlier, flawed Vygotskian perspectives. Examiner One is not immune from this trend referencing a 1986 Vygotskian publication (Kozulin, 1986), the author of which has included details of errata pertaining to incorrect interpretations of Vygotsky's original writings. Other authors, recommended by Examiner One, who also utilise Vygotsky's works which are known to be less valid in their interpretation than the 1987 publication include Brown, Stein and Forman (1996), Crawford (1996), Lerman (1996a) and van Oers (1998). Authors of articles collected for this 'update' who do utilise the more correct interpretations of Vygotsky's writings include Cobb and Bowers (1999) and Steffe and Thompson (2000).

The latter of this group is engaged in a debate with some of the former group over interpretations, meanings and uses of terms such as intersubjectivity, constructivism and social constructivism. The following extracts provide a sense of the debate:

"Temporary states of intersubjectivity" (Cobb, Wood & Yackel, 1991, p. 162) in the classroom is "one aspect of children's learning that is challenging the dominant mathematics education theoretical orientation of radical constructivism" (Lerman, 1996b, p. 133). In this work, Lerman suggests "that the extension of radical constructivism toward social constructivism, in an attempt to incorporate intersubjectivity" will lead to "an incoherent theory of learning" (Lerman, 1996b, p. 133). Lerman then posits Piaget in contrast to Vygotsky in support of his claim "that radical constructivism does not offer enough as an explanation of children's learning
of mathematics" (Lerman, 1996b, p. 133). In describing this theoretical perspective, Lerman places himself at odds with proponents of a more constructivist approach.

Steffe and Thompson (2000) react to and dispute Lerman's interpretations as the following extract illustrates:

"Lerman, in his challenge to radical constructivism, presented Vygotsky as an irreconcilable opponent to Piaget's genetic epistemology and thus to von Glasersfeld's radical constructivism. We (Steffe and Thompson) argue that Lerman's stance does not reflect on von Glasersfeld's opinion of Vygotsky's work, nor does it reflect Vygotsky's opinion of Piaget's work. We question Lerman's interpretation of radical constructivism and explain how the ideas of interaction, intersubjectivity, and social goals make sense in it. We then establish compatibility between the analytic units in Vygotsky's and von Glasersfeld's models and contrast them with Lerman's analytic unit. Consequently, we question Lerman's interpretation of Vygotsky. Finally, we question Lerman's use of Vygotsky's work in mathematics education, and we contrast that use with how we use von Glasersfeld's radical constructivism" (Steffe and Thompson, 2000, p. 191).

As a consequence, Lerman (2000) responds and begins to mediate the previously expressed views in an attempt to move the discussion forward in a collaborative way as the following extract reports:

"In their response to my (1996) article, Steffe and Thompson argued that I have taken an early position of Vygotsky's and that his later work is subsumed in and developed by von Glasersfeld. I argue that the two theories, Vygotsky's and radical constructivism, are, on the contrary, quite distinct and that this distinction, when seen as a dichotomy, is productive. I suggest that radical constructivists draw on a weak image of the role of social life. I argue that a thick notion of social leads to a complexity of sociocultural theories concerning the teaching and learning of mathematics, a perspective that is firmly located in the debates surrounding cultural theory of the last 2 decades" (Lerman, 2000, p. 210).
Finally, another party, Kieren (2000), takes the initiative and merges the perspectives of the other authors lauding the benefits to be gained from adopting a multiple theoretical perspective. The following extract summarises Kieren's approach:

"Mathematics education in schools can be viewed either as primarily a sociocultural phenomenon or as a nurturing of the individual's mathematical development. However, instead of taking the dichotomous view, contrasting the Vygotskian and the Piagetian perspectives, one may see the two as separate "truths", providing different lenses through which to attain a more complete reciprocal embodied view of mathematics education" (Kieren, 2000, p. 228).

This final statement by Kieren best reflects the process which the candidate endeavoured to achieve in his thesis. A merging of two separate 'truths' to provide a more complete perspective of the candidate's study. A multiple theoretical perspective. Thus the candidate's inclusion of recent literature as required by Examiner One, is made with an awareness that this requirement weakens the integrity which the candidate endeavoured to maintain in his thesis. Recent literature inclusions made by the candidate are detailed in Table 29 overleaf.

Examiner One stated: "I require that the candidate change the first two chapters to reflect current literature".

The candidate believes these inclusions satisfy the requirements, as stated above by Examiner One.

Works by Forman, Valsiner, Crawford, van der Veer, Ferrara and Wertsch were reviewed for, and utilised in, earlier versions of the candidate's study. His supervisor (Professor John Malone) can verify this by reference to the candidate's monthly reports, tabled throughout 1993, 1994 and 1995, and by reference to the candidate's 1500 item bibliographic reference listing. As the foci of the candidate's study emerged and the theoretical constraints were refined, and as size was an issue, these works, along with many others, were discarded in subsequent drafts. However, the candidate's review of such material meant he was using these ideas and thus his theoretical formulations were influenced by these ideas. Examiner One refers to the work of Boero which the candidate located in the proceedings of the 22nd conference of the International Group for the Psychology of Mathematics Education. Boero's (1998) comments that his development of the VEG, 'voices and echoes game', was conceived in a Vygotskian perspective.
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<th>Author cited, date and page (if relevant)</th>
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<tr>
<td>Bartolini Bussi, 1996, p. 12</td>
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<td>Bartolini Bussi, 1996, p. 36</td>
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<td>Bartolini Bussi, Boni, Ferri and Garuti, 1999, p. 71</td>
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<td>Lerman, 1996, p. 5</td>
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<td>Tharp and Gallimore, 1988</td>
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<td>Lerman, 1996, p. 2-3</td>
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In truth, Boero cites the work of Wertsch (1991) as being foundational to his VEG experiment. Wertsch draws heavily on Vygotskian perspectives. The aim of Boero's research has been to develop means of mediating knowledge which is theoretical. This is loosely analogous with the process of mediating taken-as-shared knowledge which is addressed, in part, in the candidate's thesis on p71.

Unless otherwise referenced, all "quotations" which follow are taken from Examiner One's thesis review report.

**Point 2:**

Examiner One comments that "the methodology chapter uses work that is quite old, rarely later than 1993 and most from the 1980s or earlier. Now as it happens the methodology and research methods that are used here would not be very different if the candidate had discussed more up-to-date literature although his perspective on it could have had a different orientation". This comment is noted and in particular it is noted that further analysis of the data arising from this study should be based on more recent works from the fields of ethnography, action research and postmodernism. The candidate would also note that the data for this study was collected in 1993 and thus the methodology was completely up-to-date at that time.

**Point 3:**

Examiner One acknowledges that there is "quite a muddle around constructivism, social constructivism and Vygotsky's work" and that this is "a debate, drawing in writers such as Cobb, Confrey, Steffe and Lerman in mathematics education". Examiner One also notes that "Bruner is on record as saying that you can't put Vygotsky and Piaget together". This muddle, as Examiner One calls it, remains prevalent in the great discussions among mathematics educators to this day as the candidate illustrated earlier (pages 14-15). A further example of these 'debates' can be found in Volume 26 of the Journal for Research in Mathematics Education in which Simon (1995a) reconstructs mathematics pedagogy form a constructivist perspective while Steffe and D'Ambrosio (1995) react to Simon by moving toward a working model of constructivist teaching. In response, Simon (1995b) elaborates his models of mathematics teaching. These healthy discussions do little to sort out the confusions Examiner One refers to but they do allow for a full description of the prevailing, even opposing, perspectives within present day mathematics education theory.
Examiner One notes, when commenting on the discussion about discourse, that "it is nonsense when people say (the candidate doesn't make this mistake) that Piaget was not interested in social interactions". Thus Examiner One compliments the candidate on avoiding this potential error. Examiner One also notes the candidate's misunderstanding of the use of the term mediation but Examiner One also notes that the candidate "does not use mediation all that much so this misunderstanding is not crucial". The candidate does discuss mediation on page 70 of the revised thesis. The candidate's position on discourse is again that of a Vygotskian as the candidate indicated earlier.

**Point 4:**

Examiner One asked "why didn't the candidate refer to this (the use of the zone of proximal development as an assessment tool) and try some for his class?" As indicated in his thesis, p104 and p132, the assessment processes were controlled by the school and little extra, apart from the MCI and CLES surveys, was possible without creating an over assessed environment which would have jeopardised the establishment of the desired collaborative peer interactive classroom learning environment. Also, the candidate had earlier rejected the concept of utilising the zone of proximal development itself as a performance (assessment) indicator. Early interpretations of the use of the zone of proximal development in this role had not produced findings which supported the aims of the candidate's thesis, especially not those of developing a collaborative peer interactive classroom learning environment.

**Point 5:**

The candidate relates the cultural historical facets of Vygotsky's work and the socio-cultural facets of constructivism is his thesis and the single point on p122 to which Examiner One refers was meant to be a deliberately narrow comment about the ethnicity of one of the students in relation to the remainder of the class. The candidate acknowledges that the use of the word culture is mis-leading in this context and that the phrase ethnicity would have been a better choice and this has consequently been changed in the thesis. Subsequent use, on the same page, of the word culture is meant to carry the definition that Examiner One requires of this word - relating it to the Vygotskian and constructivist paradigms upon which the thesis is founded.
Point 6:

Examiner One states that he is "completely unconvinced by the claim for a classwide zone of proximal development". Authors recommended by Examiner One do not share his perspective. Crawford (1996, p. 53 and p. 56) makes several references to the role of the zone of proximal development with groups of students and the logical extension of this is to classwide zones of proximal development. Examiner One recommends "ditching the classwide zone of proximal development notion - but it's only a recommendation". The candidate endorses this recommendation, as it relates to future developments or to future publications based upon this thesis, unless the candidate, Hedegaard (1990) or others further develop the notion of a classwide zone of proximal development.

Point 7:

Examiner One notes that "it is quite unnecessary, in the analysis in chapter 4, to continue to quote from the literature". This point is noted for future reference. The candidate believes that this was one of the positive aspects of the presentation of his thesis. It is unfortunate that Examiner One did not enjoy this manner of presentation. The thesis describes these additional references as providing an important link between the data and the literature to further strengthen the warrant of the thesis conclusions. It is pleasing to note that Examiner One did not perceive a need for this additional evidence for the warrant of the thesis conclusions.

Final point:

In his final paragraph Examiner One delineates his requirement for the candidate to change the first two chapters to reflect current literature, which the candidate has now done, and he asks the candidate to "think carefully about the constructivist elements of his theory and perhaps revise some aspects of it, or present better arguments for blending constructivism and his very well argued Vygotskian position". The candidate has thought carefully about the constructivist elements of his theory and has consulted the literature as Examiner One suggested. The candidate finds that his theoretical position is not in need of refinement as it pertains to his thesis however, the candidate's future work or publications will reflect some of the latest issues surrounding the debates over these matters, as described earlier (pages 18-19).
References:


6.3 REPORT BY EXAMINER 2

The implementation of a collaborative peer interactive mathematics classroom learning environment.

What follows is a summary of my remarks based solely on my reading of this dissertation study. I have not had the opportunity to exchange impressions with the student or with the rest of the committee, thus some of my comments may be redundant with those made by other committee members or perhaps uninformed. given my unfamiliarity with the social context of study (Western Australia). As well, some of my critical comments may have been addressed already by the student, or perhaps I missed the information in this rather lengthy dissertation.

In general, the dissertation represents an impressive attempt to put into practice, through collaborative teaching and learning arrangements, theoretical notions borrowed from several sources, as the author specifies quite well in the study. The challenge was how to design and implement such a study in a classroom setting, when the teacher was not only a researcher actively collecting data but responsible for instruction and student outcomes. Mr. Ireland did an outstanding job in developing an arrangement where he could attend to his instructional duties while collecting data systematically during the course of the study. Although he does not recommend a similar dual arrangement to other teachers who may want to follow his lead, primarily because of its laboriousness, he did complete successfully the study. He addresses well the limitations of conducting such a study, but does not offer his insights; about what aspects of the study he would modify if he were to conduct the study again. For example, would he reduce the scope of work, say, from six groups to three, in order to concentrate more on the analysis of discourse within each group? After all, within his particular mix of theoretical orientations, especially the Vygotskian formulation, discourse is assigned a powerful role as the primary mediational means for learning and development, but addressed minimally within the present study, as the author acknowledges in the final chapter. He does, however, elaborate how modifications in his own questioning and emphasis helped shape over time the collaborative characteristics of the groups. The point, however, is the he should at least specify the minimal conditions necessary for other teachers to embark on similar research, after all, he established convincingly through his dissertation the worthiness of such an effort. I also do not recall that he used any computer software system, there are now several such systems available, to help him manage the narrative or qualitative data. Such a system may have allowed him to include
transcripts from the audio and videotapes as part of his data bank to supplement his analysis. Given his experiences in conducting the study, it may be worthwhile for him to discuss how such data management systems may have enhanced his analysis or their utility for future research.

The first two chapters of the dissertation delineate well the purpose of the study as well as its theoretical and methodological emphasis. However, there are at least two aspects central to Vygotskian theory that are not addressed, although quite relevant to the design of the dissertation and its findings. One is Vygotsky’s emphasis on a “genetic” or developmental approach. An example is what he called the “method of double stimulation,” in which the experimenter devises a situation or task and provides the subject with some means (or other forms of assistance) that can load to a solution of the task. The focus is on the subject’s constructive role, on how he or she uses the available resources or creates new mediational means to solve the task or problem. Along similar lines is what Vygotsky proposed as teaching experiments,” sometimes referred to in the literature as formative” experiments, where the focus is on understanding the process of transformation towards a particular outcome, along with understanding the use of available means and resources in mediating that transformation. A second aspect that is not addressed fully in the dissertation is the Vygotskian concept of mediation, especially how different mediational means become part of the activities or central to the development of self regulation in individuals. Both aspects, especially analysing and understanding how collaborative instructional settings and accompanying patterns of speech, or other types of mediation (what Pontecorvo calls “thought methodologies”), affect forms of arguing, thinking, and learning about mathematics, are central to the present study, but not addressed in those theoretical terms. Perhaps this is a topic for a future study, especially since the author, given space limitations, did not report on several weeks worth of data that were collected later in the year.

The Vygotskian literature on teaching is also broader than what is reported in the study. To be sure, there are limitations to what can be included in any one study, but an important omission is the recent work of Gordon Wells and colleagues that highlights precisely the sort of dialogic and collaborative instructional settings that are featured in the dissertation, or for that matter the work on mathematics education of V. Davydov, who was the source of inspiration for Hedegaard’s work, that is cited in the study. (By the way, a minor point, of sorts: I am given credit for a 1994 article in the journal Human Development, but the author is actually Ian Moll, a colleague from South Africa).
I had the most difficulty with Chapter 3 on methodology. I think that a more traditional format that included separate sections on the study setting, participant selection (the total number of students is not specified until much later in the study), data collection (with separate sections on each data source), the role of the researcher, etc, would have increased the chapter's clarity. Some data sources are not discussed in the study, such as the photographs, and some sources are mentioned in parts of the study but not in others. A particularly important contribution of the dissertation study was in elaborating the "emic" perspective, the participants' points of view on the dynamics of the lessons (however, there is less on their learning within these settings). But other than the use of the MCI instrument, it is not clear how that perspective was to be obtained and elaborated. I was also surprised that the author did not include any individual case studies as part of his design and analysis, it would have contributed an important developmental perspective, and allowed elaborations on individual differences that would have helped clarify the differential student outcomes. For example, contrasting Kerry and Cathy's participation and performance. Similarly, the inclusion of all six groups gives the study breadth, but perhaps takes away from the more grounded details as found in more focused qualitative case studies.

The chapter detailing the findings, Chapter 4, is easier to read and follow because of its repetitive structure, using similar data categories to contrast the development of the settings over time, although it is a very long chapter, over 250 pages, that could have been divided for ease of reading into two or three chapters. An important contribution was the development of a more dynamic and varied concept of the zone of proximal development (zopd), as captured in terms such as "bi-directional," living concept," and "multiple" zopd. Given less attention in describing such zopds was the specification of the role played by multiple mediational means in the teaching and learning process, such as the multiple voices found within each group or the role of errors, both prominent in the study, or how to understand learning (or internalisation or appropriation) within such varied zones. It is also clear that the students did better in group worked tests that in individually administered tests (assuming their comparability), but it is not clear why the differential performance. How can the concept of the zopd help in understanding these differences? As well, the claim is made that the students established a relationship between "everyday" and "scientific" concepts, but no concrete examples are presented to establish how that occurs. For example in Marta Civil et al's recent work, they have found it quite difficult to link mathematical "funds of knowledge" as found in working-class households, with the teaching of math in classrooms. There is often a discrepancy between what counts as mathematics in home settings and what counts as math in classrooms, or what counts
as math for a mathematician doing the research (as in Civil's case). Thus, any links between homes and classrooms have to be indirect, building on some aspects of home experiences but not on others that may be less relevant or salient to the more formal math requirements of classrooms.

A few other comments: There is also the interesting point (p. 278) that time on task raises questions about the length of (individual) tests, but the point is not elaborated. And there is the claim (p. 122) that culture is not a factor because the students are all white, an odd claim, I thought; but it is also stated (and a contradiction) in the same sentence that cultural experiences based on each students' background were utilised, although it is not clear what were those experiences or how they were used in the teaching. There is also the claim that it is advantageous for actual modes of instruction to match student preferences, and the MCI was used to establish movement in that direction, but the claim is not explained, why is it more advantageous and did it make a difference in the study in terms of student learning?

I should also comment on the author's mixing of his writing with selected quotes from other authors, as in (p. 27): This is a very complex situation but "we all need to understand our own classrooms" (quotations). This rhetorical strategy occurs throughout the chapters of the dissertation, and the intent is to establish links to the literature, or so I assume. However, I think that this strategy detracts from the author's voice and diminishes his authority to make claims based, not on what other authors have written, but on his own stance and interpretation regarding his specific data. This is particularly true, I believe, in the findings chapter, where I wanted to read the author's analysis, in his own words, so to speak, without the constant "ventriloquism" through other authors.

In closing, I am impressed that the author was able to conduct such a complicated study, involving a delicate balance between his teaching responsibilities and research purposes. Clearly, in this study the participant in "participant observer" was much more than metaphorical, as is usually the case in qualitative research. In conducting this work, Mr. Ireland has made a valuable contribution to the research literature, and especially to the literature on teacher research, a valuable approach to educational research. He has also managed to combine a well specified theoretical orientation and use it to guide his actions as a teacher researcher, also a deviation from the usual atheoretical attempts in this type of work. In short, Mr. Ireland has contributed both theoretically and empirically through his dissertation study. It would be a shame to detract others from attempting such studies, although I know that is not the author's intent. His intent is to provide others with a frank and well documented analysis of what it takes to be both teacher and researcher within concrete classroom conditions.
6.4 RESPONSE TO EXAMINER 2

Unless otherwise referenced, all "quotations" which follow are taken from Examiner Two's thesis review report.

Examiner Two has made several pleasingly positive comments through his review of the dissertation.

Examiner Two stated: "The dissertation represents an impressive attempt to put into practice, through collaborative teaching and learning arrangements, theoretical notions borrowed from several sources, as the author specifies quite well in the study. Mr. Ireland did an outstanding job in developing an arrangement where he could attend to his instructional duties while collecting data systematically during the course of the study - he did complete successfully the study. He established convincingly through his dissertation the worthiness of such an effort. The first two chapters of the dissertation delineate well the purpose of the study as well as its theoretical and methodological emphasis. A particularly important contribution of the dissertation study was in elaborating the 'emic' perspective, the participants' points of view on the dynamics of the lessons".

Through his report, Examiner Two engaged the candidate in discourse on aspects of the study where Examiner Two would have preferred an alternative approach. The candidate has summarised this as follows. Examiner Two has commented on his desire to have had this study focus more pointedly on smaller specific aspects of the environment. This can be evidenced from his comments regarding the 'genetic' aspects of Vygotskian theory and also his penchant that the study had only focused on three rather than six groups, an idea he suggests be followed by future researchers replicating this study. This latter point, regarding the path that future or follow-up research might pursue, has been taken up by the candidate in the form of an addition to the Implications and Recommendations section of the dissertation. The candidate has considered and reflected on all aspects of Examiner Two's dissertation review report and presents the following review as evidence of his reflections - the other half of the discourse between Examiner Two and the candidate.

Examiner Two asked the candidate "what aspects of the study he would modify if he were to conduct the study again" and noted that the candidate should "at least specify the minimal conditions necessary for other teachers to embark on similar research". Examiner Two recommended to the candidate that "it may be worthwhile for him to
discuss how data management systems may have enhanced his analysis or their utility for future research". The candidate has followed up on these suggestions, as far as recommendations and guidelines for future research are concerned, by including a paragraph on these aspects of the study in the Implications and Recommendations section of the thesis as shown below.

- future research, along a similar design, may be further enhanced by considering the following ideas:
  - teachers carrying out such research should have one less class, the equivalent of a 20% reduction in workload, to be able to facilitate the methodological requirements of such research.
  - utilising a computer software system to manage the narrative or qualitative data would allow the research to include more transcripts from audio and videotape sources to supplement the data analysis.
  - future research could adopt the Vygotskian model of a 'teaching experiment", also known as a formative experiment, to focus on understanding the transformation towards a particular outcome. This may be especially meritorious given the new trend towards outcomes-based education processes (CC, 1998).
  - a future study may benefit from focusing on the changes related to only three groups, or ten to twelve students, rather than the six groups, twenty one students, observed in this study.

Examiner Two noted that one aspect, central to Vygotskian theory, not addressed yet quite relevant to the dissertation, was Vygotsky's "genetic" developmental approach. The candidate acknowledges this and notes that this aspect of Vygotskian theory was extensively researched by the candidate in the early stages of his research work. Reference to this can be found in the candidate's presentations to his research colloquia group, made in 1992, 1993 and 1994, as well as in the candidate's many summaries of writings about Vygotsky. The candidate has detailed the 'genetic' orientation of Vygotsky's early work especially commenting on the ontogenetic and phylogenetic facets of Vygotsky's culturally centred research. Examiner Two's interest in the 'micro' is analogous to his interest in Vygotsky's ontogenetic work. These facets had little bearing on the final stance of the research undertaken in this study as the nature of the candidate's research, focusing on the class as the unit of analysis, or taking on a more holistic perspective of the class, did not facilitate such a microscopic analysis of the context, the participants or the setting, and thus the candidate, in accord with advice from his supervisors, did not explore this facet of Vygotskian theory in this study.
Another aspect of Vygotskian theory, discussed by Examiner Two, is what the literature called teaching or formative experiments. The candidate did not claim to be carrying out such types of research as he was aware that his study differed from these types in its basic structure and execution. The candidate has adjusted his dissertation and referred to these research forms in the revised recommendations section presented above.

A final aspect of Vygotskian theory, referred to by Examiner Two, is the Vygotskian concept of mediation. While Examiner Two notes that aspects of mediation are referred to throughout the dissertation he is correct when he points out that this concept is not well developed in the theoretical section of the dissertation. As noted above, this is a section of Vygotsky's theories which was deemed to be of lesser significance to this study and thus it did not receive full theoretical development in the dissertation. Thesis length restrictions, as Examiner Two acknowledges, also had a bearing on just how much theoretical development of Vygotsky's ideas could be included in the dissertation. However, aspects of mediation have been enhanced in the dissertation for, as Examiner Two notes, his comments reflect those of others involved in the examination of the study. As noted earlier, the candidate has updated the literature, on several points to do with mediation, at the request of Examiner One who gave specific indications on how this could be done. Examiner Two comments that the Vygotskian literature on teaching is broader than reported in the dissertation but acknowledges again that "there are limitations to what can be included in any one study". Future research following on from this study must address this point especially noting the work of Gordon Wells and D. Davydov, as recommended by Examiner Two.

Examiner Two's desire for "individual case studies" and his comments regarding "the inclusion of all six groups" further reflects his preference for a 'micro' rather than 'macro' perspective. In the initial stages of data collection, the candidate endeavoured to collect data which focused on individuals. This led to the realisation of two complications. The first complication was the intrusive nature of such data collection processes into our developing environment. The negative reactions to this form of information gathering led to the cessation of its use. The second complication was the excessive consumption of time, required for the representation and analysis of this form of data. The candidate could not sustain its use in the teacher / researcher work environment.
Examiner Two states that "a more traditional format would have increased the (methodology) chapter's clarity". A more traditional format, as described by Examiner Two was not considered by the candidate nor was it ever suggested by the candidate's supervisors, peers at colloquia or the literature. The design selected matched the combined ethnographic / action research model which the study utilised. Examiner Two also comments that photographs as a data source were "not discussed". This section was another late deletion from the thesis as a result of length restrictions.

In discussing Chapter 4, Examiner Two notes that "the chapter detailing the findings, Chapter 4, is easier to read and follow because of its repetitive structure, using similar data categories to contrast the development of the settings over time. An important contribution was the development of a more dynamic and varied concept of the zone of proximal development (zopd), as captured in terms such as 'bidirectional,' 'living concept,' and 'multiple' zopd". Examiner Two also provides several excellent notes regarding the further development of the research method applied in the study. His discussion of the zone of proximal development and the related work by Marta Civil are certainly worth noting for future extensions of the study.

Examiner Two points out, as did Examiner One and Examiner Three, that the mix of the candidate's "writing with selected quotes from other authors detracts from the author's (candidate's) voice". Examiner Two describes this process, as did Examiner Three, as "ventriloquism". The candidate notes, and recommends that future researchers note, that this form of writing practice is not acceptable in such research.

Examiner Two concludes his review with the following complimentary remarks. "I am impressed that the author was able to conduct such a complicated study, involving a delicate balance between his teaching responsibilities and research purposes. In conducting this work, Mr. Ireland has made a valuable contribution to the research literature, and especially to the literature on teacher research, a valuable approach to educational research. He has also managed to combine a well specified theoretical orientation and use it to guide his actions as a teacher researcher, also a deviation from the usual atheoretical attempts in this type of work. In short, Mr. Ireland has contributed both theoretically and empirically through his dissertation study".

The candidate has completed all tasks required of him by Examiner Two.
The candidate wishes to express his thanks to Examiner Two for his highly stimulating and insightful review of the dissertation. Examiner Two's report has provided very positive support for the research undertaken by the candidate and has given the candidate very good direction as to how his research can be further developed.

6.5 REPORT BY EXAMINER 3

The implementation of a collaborative peer interactive mathematics classroom learning environment.

This thesis documents and analyses the author's work in establishing a collaborative learning environment in his Year 8 mathematics classroom over a period of six months. Drawing on multiple but related theoretical perspectives, the author constructed a coherent rationale for teacher and student activity which he then sought to actualise in his own classroom. The specific aims of the research were both practically and theoretically framed – to develop an effective collaborative learning environment, and to analyse teacher-student and student-student interactions so as to inform further development of such classroom arrangements.

The thesis represents a significant research undertaking and provides ample evidence of the author's ability to plan and conduct a well thought out research program. Especially noteworthy from a practical point of view are the siting of the study in the author's own classroom, and the choice of Year 8, the first year of secondary schooling, as the level for study. The credibility of the findings is enhanced by such choices, which also defined the possibilities and limits of this teaching experiment.

Theoretically and methodologically the thesis possesses a number of strengths. The author has read widely in fields of study relevant to the research, and has developed promising elaborations of several theoretical concepts that are likely to be useful to both researchers and classroom teachers. For example, the study is well positioned as an exploration of the potential to coordinate sociocultural and constructivist perspectives as suggested by Paul Cobb. Significant also are formulations of peer collaborative and classwide zones of proximal development that extend the more widely held notion of a ZPD created through adult-child interaction characterised by differential expertise, and the conclusion that internalisation is better characterised as a move from joint to self-regulation than other to self-regulation. The research findings and conclusions are based on a very substantial data corpus, consisting
mainly of lesson observations and audiotapes recorded by the author and summarised daily, weekly, and monthly. It is clear that much careful thought has gone into the preparation and documentation of this teaching intervention.

Despite these positive features, however, I feel there are some aspects of the thesis that deserved more careful attention. In particular, there are many errors of presentation that should be corrected before awarding the degree (I have marked these in the margins and appended a list of relevant page numbers.) My comments from this point are intended as suggestions to the author should he wish to publish from the thesis or to conduct further research in this area.

The literature review suffers in part from a lack of critical analysis of inconsistencies between sociocultural and constructivist perspectives on learning. While both see a role for social interaction in promoting learning, these theories differ in their underlying assumptions about the nature of this role and the priority accorded to individual versus social processes. Similarly – and despite the caveat regarding collaborative versus cooperative work in Chapter 1 – the author could have distinguished more carefully between approaches to peer learning rather than treating the literature in this area as essentially homogeneous. For example, it is incongruous to cite Slavin on "collaborative learning" as his approach has been criticised for emphasising extrinsic rewards and narrow achievement outcomes over complex thinking processes. From a stylistic perspective I also found it unusual to see so much use of direct quotation in lending support to developing arguments and (in Chapter 4) in linking findings to the literature. (In fact, I cannot help questioning their veracity as material attributed to Goos & Geiger was certainly not quoted verbatim!) This technique is clumsy and distorts the author's own voice as a legitimate researcher.

The methodology of the study, although contextually and substantively appropriate, highlights the inevitable difficulties and contradictions in the roles of a teacher-researcher. While this is dealt with quite nicely in Chapter 3's analysis of action research and ethnographic methods, I wonder whether the problem is not so much one of becoming one of the group researched as one of stepping outside the group of which one is already a member – that is, distancing oneself from one's own actions as "the teacher" and adopting a more self-critical stance, especially towards "disconfirming evidence". For example, the author notes that one significant outcome was the change in himself – and yet nowhere is this analysed. (It would be interesting also to learn of the dilemmas faced by the author in teaching four other classes that did not operate along the lines of the research classroom.) Perhaps this
difficulty could be addressed by recording both classroom observations (which could take on a more detached tone) and self observations (captured in a reflective journal) and treating these as separate data sources.

Finally, the data narrative – while extensive and thorough – would benefit from a more focused analysis and interpretation. Significant themes and trends are easily obscured by the sheer mass of data. A series of vignettes, consisting of carefully selected observations illustrated by task details and transcripts of student and teacher talk, may provide more convincing and accessible evidence of the development of the classroom learning environment. Despite the author’s defence of the data reduction process, and the dearth of verbatim transcripts of classroom talk, this reader found that even the material presented as raw data revealed no more than tantalising glimpses of the classroom at work.

There is much scope for further research that builds on this study and addresses more tightly formulated questions than those dealt with here. For example, the notion of multi-voiced discussion is worth following up, and the social interactive processes that actually create collaborative zones of proximal development deserve closer analysis. The contradiction between individual assessment and collaborative learning also has practical implications for teachers and educational systems. Given the very demanding nature of this type of research, the author rightly identifies a role for collaboration between school and university based investigators in prosecuting classroom based research – this in itself is a worthy outcome of the author’s doctoral study.

6.6 RESPONSE TO EXAMINER 3

Unless otherwise referenced, all "quotations" which follow are taken from Examiner Three’s thesis review report.

Examiner Three has made many pleasingly positive comments through her review of the thesis especially in the first three paragraphs of her review.

Examiner Three highlights aspects of the study which are worthy of more careful attention than they were afforded in the thesis.
The first of these relates to errors of presentation. Examiner Three required that these presentation errors be corrected and highlighted each instance by marking locations in the thesis margin.

ALL of these corrections have been made.

Examiner Three then kindly outlined other concerns which the candidate will heed as advised. The matters Examiner Three raised are particularly relevant to the pursuit of further research or publications arising from the candidate's study. They included:

(i) the need to critically analyse "inconsistencies between sociocultural and constructivist perspectives on learning".

(ii) the need to distinguish "more carefully between approaches to peer learning".

(iii) the possibility of adopting a stance of researcher "outside of the study group" rather than "one of becoming one of the study group". That is, "distancing oneself from one's own actions as 'the teacher'". By "adopting a more self-critical stance" the researcher (candidate) would be able to enhance the "disconfirming evidence" collected in such research.

(iv) Other recommendations made by Examiner Three:
   a) include or extend the study through an analysis of the teacher change described only briefly in the candidate's thesis;
   b) consider "the dilemmas faced by the" candidate "in teaching four other" non-collaborative "classes".

The recommendations made in points (iii) and (iv) above "could be addressed by recording both classroom observations (which could take on a more detached tone) and self observations (captured in a reflective journal) and treating these as separate data sources.

Examiner Three notes that she "found it unusual to see so much use of direct quotation in lending support to developing arguments and lining findings to the literature in Chapter 4". This comment reflects a similar comment made by Examiner One. The thesis describes these additional references as providing an important link between the data and the literature to further strengthen the warrant of the thesis conclusions. Examiner Three's comment is noted for future reference. The candidate believes that this was one of the positive aspects of the presentation of his thesis. It is unfortunate that Examiner Three found this technique "clumsy" and that it distorted "the author's own voice as a legitimate researcher".
In a further comment, Examiner Three notes that "the data narrative would benefit from a more focused analysis and interpretation". To attain "more convincing and accessible evidence of the development of the classroom learning environment" the candidate could consider writing "a series of vignettes, consisting of carefully selected observations illustrated by task details and transcripts of student and teacher talk".

Examiner Three states that "there is much scope for further research that builds on this study". "For example, the notion of multi-voiced discussion is worth following up, and the social interactive processes that actually create collaborative zones of proximal development deserve closer analysis. The contradiction between individual assessment and collaborative learning also has practical implications for teachers and educational systems".

Examiner Three concludes her review with the following complimentary remark. "Given the very demanding nature of this type of research, the author (candidate) rightly identifies a role for collaboration between school and university based investigators in prosecuting classroom based research - this in itself is a worthy outcome of the author's doctoral study.

The candidate has completed all tasks required of him by Examiner Three.

The candidate expresses his thanks to Examiner Three for her detailed review of and reflection on his research as reported in his thesis.