Science and Mathematics Education Centre

The Impact of a Blended Web-based Learning Environment on the Perceptions, Attitudes, and Performance of Boys and Girls in Junior Science and Senior Physics

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ABSTRACT

In some classrooms, teaching methods have evolved little over the years. Enrolments in subjects like science have progressively declined and the persistent use of traditional teaching methods has often been held responsible for this. In less than a decade, the Internet has emerged as a potential tool to vary classroom routines, however, its use in high school science classrooms is still in its infancy. In this study, *Getsmart,* a website was developed and implemented in junior science and senior physics classrooms in a blended learning environment in a Queensland State High School. The study had three main objectives amongst others. The first aim was to study the impact of such an environment on students' perceptions. Secondly, the impact of such an environment on students' attitudes towards physics and junior science was studied. Finally, the research sought to investigate the effect of such an environment on their learning outcomes. *Getsmart* was developed on the principles of cognitive apprenticeship teaching model (Collins, Brown, & Newman, 1989). During the research phase, the website was accessed by students once a week during class time. They also had the option to login in their own time at school (e.g., morning tea, lunchtime, before and after school) and at home. The research was conducted as a case study over two years and during this time, 406 students in junior science and physics participated. Students' perceptions of their learning environment were ascertained through quantitative and qualitative methods. Quantitative data were collected by using a modified version of the *Web-based Learning Environment Instrument* (WEBLEI) (Chang & Fisher, 2003). Qualitative data on student's attitudes were gathered through emails and written surveys. An *Attitude to Science* survey was developed to determine students' attitudes towards their subjects. Qualitative data were also gathered through written surveys. The impact of such an environment on students' learning outcomes was determined through the analysis of their exam results achieved before and after experiencing web-based learning. Their results were also compared with the results of similar cohorts in previous years. Amongst other findings, it was found that the modified version of the WEBLEI was a valid and reliable instrument for use in junior science and physics classes. The study also established that students had positive perceptions of a blended web-based learning environment and that such an approach had a positive influence on students' attitudes towards their subjects. The study also found that web-based learning improved their performance across various performance domains of junior science and senior physics assessments.

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You have to expect things of yourself before you can do them. These profound words of basketball superstar Michael Jordan probably sum up my personal beliefs before I embarked on this study. As a child, my parents expected things of me and their beliefs and expectations became a part of my life as I aged like a bottle of red wine. A few years ago, the challenges of undertaking this research project would have been no more than a dream. In less than four years, I was able to transform this dream to reality. Understandably, apart from my own effort and perseverance, many others willingly gave me their support and advice.

Firstly, I would like to thank my supervisor, Professor Darrell Fisher for his guidance, encouragement, and support for my work. This thesis explored the impact of a web-based learning environment on high school students. The geographical isolation between Perth and Brisbane made me a prime candidate for assessing the impact of a web-based learning environment on a doctoral student. In my case, it was perhaps the speedy response to my emails by Professor Fisher that convinced me that I was not alone. The fact that I was a student at distance did not matter. Professor Fisher's quick responses to my queries emphasised the importance of educators in such environments. The roles of Professor Barry Fraser as the chairperson of the thesis panel and Professor David Treagust as associate supervisor are also acknowledged.

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CHAPTER 1

INTRODUCTION AND OVERVIEW

1.1 INTRODUCTION

What are some issues in science education? Several studies (e.g., Goodrum, Hackling, & Rennie, 2001; Millar & Osborne, 1998) in recent times have produced a less than desirable report card on science education. According to the researchers the content did not seem to connect with the majority of the learners. More importantly, the manner in which this content was delivered was also an issue. Consequently, enrolments in science subjects had declined. But what can classroom teachers do about it? After all teachers have a limited input in terms of the design of polices and curriculum framework.

Is a blended web-based approach to teaching science the answer? Following the widespread success of the Internet, web-based learning offers real hope for educators worldwide to vary and deliver their lessons in a user-friendly manner, thus adding variety to existing traditional teaching methods. Children are now more able to use computers and related technologies than are their teachers (Eklund, Kay, & Lynch, 2003; McInerney & McInerney, 2002). Technological advancements in the past decade have created teaching and learning opportunities of significant proportions, which would have been a fantasy a few years ago (Dierker, 1995). Packer (as cited in Linnell, 2003) believed that business and industry viewed it as a smarter medium. Rickards (2003) pointed out that for counties to be globally competitive, investment in ICT is essential. However, he also alluded to the fact that using these technologies in a meaningful way is equally if not more important. It is probably for this reason education authorities worldwide have injected trillions of dollars (MacFarlane, 2000) for acquiring Information and Communication Technologies (ICT). Yet, despite the increasing availability of ICT in schools, a significant proportion of the students have never used computers in their schoolwork nor looked for information on the Internet at school (Goodrum, Hackling, & Rennie, 2001).

In a high school environment, the use of the Internet in a blended environment is a realistic and feasible option. In this study, a website (*Getsmart*) was developed to supplement the teaching of senior physics and junior science in a Queensland State High School. A teacher (the researcher), with no in-service or training in ICT related fields, developed the website. In this research, it was assumed, that if students had positive perceptions of their web-based learning environment, then this should reflect in their attitudes and eventually in their performance in their subjects. Hence, in this study the perception of students of a web-based learning environment and its impact on their attitudes and performance in junior science and senior physics was studied. The presence of any relationships between these variables and any variations based on gender and subject was also explored.

1.2 BACKGROUND OF THIS STUDY

If Darwin's theory of evolution is correct, then the human race must have evolved to a certain extent since the first classrooms were created to educate the members of this species. Have the classrooms evolved to meet the needs of the new breed of humans? According to Connick and Russo (as cited in Fowler, 1995, p. 215) education systems are periodically redefined to meet the evolving needs of the society, "yet in teaching changes are occurring sporadically and in relative isolation". They also pointed out that "teachers of 100 years ago could enter a classroom of today and take over" whereas a surgeon from that era may have difficulties functioning effectively in today's operating theatres.

The inability of the schooling system to meet the needs of the ever-changing human population has probably led to serious problems in school subjects such as science. According to Lowe (*Science Initial in-service materials*, 1999, p. 24), science education is still based on the "Moses model", where the "elderly, usually male, expert brings down the tablets of stone carrying eternal verities....students are expected to memorise the contents". Consequently, many students view science as boring and irrelevant and have a where will I use this attitude. Goodrum, Hackling, and Rennie (2001) produced a comprehensive report titled *The Status and Quality of Teaching and Learning of Science in Australian Schools* on issues that related to science education. The authors began by pointing out that on average, the actual picture of science was "disappointing" and the quality of teaching ranged from "brilliant to appalling" (Goodrum, Hackling, & Rennie, 2001, p. 85). As a result of this grim picture, enrolments in science have probably diminished significantly and according to Harrison (as cited in Roberts, 2002, p. 13), science "was in danger of becoming an optional snack in a smorgasbord of subjects".

Many new technologies have emerged over the years and their successes have been firmly grounded in scientific concepts, yet these achievements have induced little desire amongst the present generation to study science. The first moon landing was an example of the extent to which science could become exciting. Some issues in science have remained in "the hard decision basket" for years. Gender issues relating to science subject selections have been an issue for some time. The widening gap between the academic performance of boys and girls is not necessarily an isolated science issue, yet it is of great concern.

The declining interest in science is not a recent problem. Twenty years ago, an issue concerning science educators was the participation and performance of girls in science. In 1984, the Dircks Report pointed out that girls' attitudes to science influenced their subject choices, which consequently disadvantaged them in their career prospects (Australian Science Teachers Association, 1987). This report led to a national symposium, held later that year, which identified two key problems. Firstly, science courses were not addressing the needs, interests, and abilities of many students. Secondly, there was a low participation of females in science and science education.

Despite all these initiatives, is science education any better off? While the proportion of students completing year 12 education has doubled in the past 20 years, the proportion of students who enrolled in biology, physics, and chemistry has dropped (Goodrum, Hackling, & Rennie, 2001, p. 42). Given that these subjects are viewed as difficult, even the more able students choose other options. Goodrum, Hackling, and Rennie's research also pointed out that students found science to be "neither too easy nor too hard" which suggested that the often perceived level of difficulty may not be the issue.

Then what is the problem? Perhaps the answer lies in the way science is taught. Millar and Osborne (1998, p. 2005) suggested that the science taught in the UK was "a catalogue of discrete ideas, lacking in coherence and relevance." According to Goodrum, Hackling, & Rennie (2001) the content did not connect with students interests and experiences. One participant in their survey pointed out that "secondary schools put out the fire of desire that is lit in primary schools" (p.86). Consequently, their desire for studying science at school diminished. Their finding also noted that chalk and talk teaching, copying notes, and cookbook type practical lessons dominated science lessons. These teaching methods induced little excitement or enjoyment amongst the students. Sixty-one percent of the students claimed to have written notes every lesson and one third of the population requested for more practical and hands-on work (Goodrum, Hackling, & Rennie, 2001). "Variety is the spice of life" – this does not seem to apply to teaching methods in many science lessons.

Does science need a new teaching approach? In this research, the impact of web-based learning (in a blended environment) on the perceptions and performance of boys and girls in senior physics and junior science classes is studied.

1.3 RATIONALE OF THE STUDY

Sarason (1993) believed that there was an overwhelming desire amongst learners to engage in learning with different teaching methods. He pointed out that the present "one-size fits all delivery system" (p. 1) had failed the learners. The current approach where everyone supposedly learns the same thing at the same time, irrespective of the learners needs has not always optimized learning outcomes. Consequently, if teaching methods do not capture learners' attention, little or no learning takes place. According to Jensen (1998), there are two groups of factors which influence attention for learning. Jensen suggested that learning which was relevant, offered choices and was engaging increased "intrinsic motivation". Such learning also had the potential to "hook attention for 10-90 minutes" (p.48). On the other hand, Jensen (1998) also pointed out that learning which lacked choices was irrelevant and passive increased apathy and resentment. Such learning hooked attention for less than 10 minutes.

Today's children speak the language of technology better than the generations before them. Many young people of today have grown up with multimedia and related ICT's (McInerney & McInerney, 2002). In Australian Schools, many students are now more capable of using computers than their teachers (Eklund, Kay, & Lynch, 2003). Perhaps one way to reverse trends observed in science in the past is by using a student-friendly medium of interaction, which uses ICT's.

The Internet is now more accessible in homes and schools than it has ever been. A lot of public funding has been directed towards the acquisition of ICT's. However, the use of these technologies in science has been minimal. According to Goodrum, Hackling, and Rennie (2001), 67% of science students had never used computers in their school work and 54% had never looked for information on the Internet at school. Lack of teacher in-service has often been blamed for such deficiencies.

Brooks, Nolan, and Gallagher (2001, p. 4) argued that the Internet was "changing both what we teach and how we teach it" but they also pointed out that purposeless surfing of the net did not improve learning outcomes. McInerney and McInerney (2002, p. 163) pointed out that "the mere use of the computer is not sufficient to create a positive cognitive change". Similar views were echoed by Wang and Bonk (2001, p. 149) who suggested that the "success of technology-based learning environments does not rely solely on technology. Considerations of human cognition and the social context of that thinking take precedence over technology." Consequently, in this study, *Getsmart,* a teacher designed website was used by junior science and senior physics students. A teacher with no in-service or training in ICT and with minimal professional support designed the website. The design of *Getsmart* was also aimed at demonstrating that teachers with almost no professional development can create meaningful learning opportunities for their students on the Internet. Motivation and determination were more important perquisites than structured teacher in-service as has been suggested in many reports and studies (e.g., Goodrum, Hackling, & Rennie, 2001).

Brooks, Nolan, and Gallagher (2001) pointed out that students who were poor at self-regulation could easily be destroyed in web-based courses. In order to ensure that all students have an equal opportunity for participation, the web-based learning in this study was offered in a blended learning environment. The website design was based on the "electronic cognitive apprenticeship model of teaching" (Collins, Brown, & Newman, 1989; Wang & Bonk, 2001, p. 131). While most of the methods of the cognitive apprenticeship model were not new, they collectively delivered an effective learning environment in which learners and teachers were able to perform different roles (Berryman, n.d.). The cognitive apprenticeship model also proposes that learners should be exposed to "a variety of methods that systematically encourage student exploration and independence" and teachers should provide scaffolding and gradually "fade…handing over control of the learning process to the student" (Berryman, n.d., p. 4). With such an approach, teachers involve their students in their learning (Collins, Brown, & Newman, 1989). The design of *Getsmart* enabled students to interact and utilize the website through a variety of methods that created these opportunities.

Research into students' perceptions of such an innovative teaching approach is important because it ensures further development. Fortunately, in the field of learning environments, the impact of such innovations on students can be effectively measured. For more than 30 years, proven qualitative and quantitative research methods associated with learning environments have yield productive results for educators. In this study, the perceptions of web-based learning in a blended environment were measured using a modified version of the *Web-Learning Environment Instrument* (WEBLEI) (Chang & Fisher, 1998). If students felt good about their learning environments, then this was more likely to be transformed into favourable learning outcomes.

In most innovative practices that rely on public funding, the question of does the initiative enhance learning outcomes is always asked. Globally trillions of dollars are spent on acquiring ICT's (Macfarlane, 2000) and the public perception is that such huge investments should deliver improved learning outcomes. This view was reflected by Michael Schrage of the Los Angeles Times who wrote that "Computers are irrelevant to the quality of education…Any school board that would import computer technology without insisting on explicit guarantees for improved student performance deserves to be impeached, voted out of office or sued for malpractice"

(Dierker, 1995, p. 229). Hence, in this research the effect of web-based learning on learning outcomes were investigated. Qualitative data were also collected to ascertain if students felt that the web-based approach enhanced their learning in science and physics. The data produced through these surveys were compared with students' actual exam results.

1.4 RESEARCH QUESTIONS

The purpose of this investigation was to determine the impact of a blended web-based learning environment on students' perceptions and subsequently its influence on their attitudes and performance in junior science and senior physics. Any variations because of gender difference or subject were also investigated. The web-based learning was primarily dependent upon a teacher-designed website. Specifically, the research attempted to address these questions:

1. Is the modified version of the Web-based Learning Environment Instrument (WEBLEI) a valid and reliable instrument for use in junior science and senior physics classes?
2. What are student perceptions of their web-based learning environment? Why do students have these perceptions?
3. Is there any difference in students' perceptions according to subjects, gender, teachers, and academic ability groups?
4. What are student attitudes to junior science and senior physics? Do students' attitudes to their subjects change after they have experienced web-based learning? Why do students attitudes change?
5. Do students think that the web-based learning approach improves their understanding in science or physics?
6. Do exam results in physics suggest that student academic outcomes are influenced by a web-based learning approach?
7. Do exam results in junior science suggest that student academic outcomes are influenced by a web-based learning approach?
8. Is there any difference in academic achievement according to gender?

1.5 OVERVIEW OF METHODOLOGY

In this study, the impact of a teacher developed website in a blended learning high school environment was studied. The website, *Getsmart* was developed by the researcher who was also one of the teachers whose students were involved in this study. The research was conducted at a state school in Queensland, Australia. Over a two-year period, 406 students were involved from 15 classes in three subjects - junior science, advanced junior science and senior physics (Years 11 & 12). The research was fitted into an existing school timetable. Almost no special privileges were given or provisions made by the school to accommodate the research. For this reason, Internet access during school time was the most significant limiting variable that dictated the sample size.

Whenever the opportunity was available, web-based lessons were designed for students which lasted for a school term. Each student was given the opportunity to access *Getsmart* and associated web resources for one lesson a week which lasted for approximately 30 minutes. They also had the option to use *Getsmart* in their own time (at school and outside school).

According to Patton (1987), research findings based on one method of data collection could be unreliable because there are strengths and weaknesses of all data collection strategies. The use of more than one "data collection approach permits the evaluator to combine strengths and correct some of the deficiencies of any one source of data" and triangulation "increases the strength and rigor of an evaluation… by building checks and balances into a design through multiple data collection strategies" (Patton, 1987, p. 60). Therefore, in this study qualitative methods such as written questionnaires, emails, chat analysis, online questionnaires and quantitative findings of the WEBLEI and an attitude survey enabled data collection and analysis from different vantage points. At the completion of their study in a blended web-based environment, students were administered with a written questionnaire, the WEBLEI, and an attitude to science (or physics) survey whenever appropriate. Other forms of data collection (e.g., emails and online questionnaires) occurred during course of the study.

The data generated through the WEBLEI were coded and analysed using *Statistical Package for the Social Sciences* (SPSS). Data gathered through questionnaires and emails were analysed using *Microsoft Access*. Results of in class tests were analysed using Microsoft Access and *Microsoft Excel.*

1.6 SIGNIFICANCE OF THE STUDY

Web-based learning will be more "effective when applied within model" (Whitlock, 2001, p. 190). Whitlock believed that there was a decline in the use of such models and the design framework of many of these did not seem to have any theoretical basis. Consequently, he believed that "poor standards of course design" (p.190) were widespread in many open and distance learning applications. Open and distance learning institutions have been the pioneers in implementing the Internet as part of their teaching regimes. He went on to make another interesting point:

> ...one of the factors that inhibits the development of a model for instructional design that practitioners can readily apply is that much of the work on new models has been carried out by what has been called the REAR (Research Academy Reform) community. The REAR community has tended to focus on general descriptive theoretical models rather than the goal-directed models that are more likely to be of immediate use to practitioners...What is required is the development of a plain-language designer's practicum using up-to-date model of instructional design on which to base a development programme for practicing course designers.
>
> (p. 190)

Whitlock also pointed out that the majority of "course designers and developers in the corporate sector lack the skills that are fundamental to the successful production of learning materials...this is particularly damaging when the intended materials are intended to stand alone" (Whitlock, 2001, p. 190). McInerney and McInerney (2002) also expressed their concerns in terms of the real impact of ICT's:

> Nowhere in educational circles is there more disagreement than the impact of computer-based technologies in classrooms of today and tomorrow...the lack of a consistent body of strong research evidence either to support or counter claims about the advantages of these technologies for learning and equity makes us cautious...we are very conscious that theories of how different components of what we might call "learning" can be enhanced by the many computer-based technologies are still in their infancy.
>
> (p. 156)

The arguments of Whitlock (2001) and McInerney and McInerney (2002) highlighted above suggests there was a need for more "goal directed" ICT models designed by practising educators that had the capability of providing research evidence in terms of what worked and why and how it influenced student learning. This research attempts to address all these issues. *Getsmart* was developed by a practising high school teacher with no formal computer related qualifications or in-service. The features of the website are built on aspects of the instructional methods of "electronic" cognitive apprenticeship (Collins, Brown & Newman, 1989; Wang & Bonk, 2001). Hence, this study aimed to demonstrate how a website designed on this model impacts on students' perceptions to a web-based learning environment. Additionally it's effect on students' attitudes and performance in science and senior physics was also investigated.

The findings of this research could be significant to practising teachers worldwide and may not be confined to science alone. The development of a website on sound educational principles of cognitive apprenticeship creates a user-friendly medium which can enable educators to reach their learners and vice versa. It also appears that many teachers do not incorporate web-based options in their teaching (Goodrum, Hackling, & Rennie, 2001; Whitlock, 2001). For many, a lack of in-service or appropriate training is the excuse. This study demonstrates that with the right motivation, teachers can create meaningful learning opportunities on the World Wide Web without the need for extensive training. The results of the students' perceptions, attitudes to science and performance in science add weight to the value of this innovative teaching approach. Collectively the research may enhance practising teachers' confidence in using the Internet in their teaching.

Additionally, education authorities worldwide are pouring in trillions of dollars to provide their students with the best that ICT have to offer. Coupled with this investment is the re-design of teaching and learning pedagogies. *Education Queensland* for instance, is at present in the process of implementing the *Education and Training Reforms for the Future* (ETRF) agenda which is viewed as one of the single most advanced integrated reform agendas in recent times (Crankston, 2004). This agenda has five key initiatives: extension of the senior schooling phase; focus on middle phase of learning; spotlight on the science program; ICT for learning strategy; and the introduction of a preparatory year of schooling from 2007. Each of these initiatives has a detailed outline of benchmarks. For instance, ICT are expected to be integrated in the curriculum in order to "deliver learning outcomes across 40 per cent of subject and or learning areas...by the end of 2005" (*Information and Communication Technologies for Learning*, 2004, p. 15). This study directly addresses three of the five initiatives. The findings of this study will demonstrate how ICT can be integrated in the science curriculum to influence learning outcomes of students in the senior school. To a certain extent, it can also be used to justify the massive injection of funds in education.

1.7 LIMITATIONS OF THE STUDY

This research was a case study which examined the impact of a blended web-based learning environment on students' perceptions, attitudes, and performance in science and physics in a state high school. The design and application of *Getsmart* was the centre piece of this study. While the findings reported explore the impact of such an environment on students, these results are largely dependent on the quality of the website. For this reason, the findings cannot be extrapolated and generalized to web-based learning in all instances.

Other factors such as sample size, teacher expertise and enthusiasm, quality of Internet connection can also have an impact on the results.

1.8 OVERVIEW OF THE THESIS

The layout of the thesis reviews relevant literature and then addresses the research questions through data analysis and discussion. The thesis has 13 chapters that are divided into five sections – Introduction, Literature Review, Research Methodology, Results and Discussion, and Conclusions.

Chapters Two to Four present the literature review of the three areas relevant to this study – learning environments, technology in education, and science education. Chapter Two contains a review of the field of learning environments. The historical perspective of this field is given followed by a discussion of the development and use of learning environment questionnaires. A time-line of the key developments is presented to highlight the evolution of these questionnaires. A selection of research findings relevant to this investigation is presented.

Chapter Three is an exploration of the role of technology in learning. Some current general issues of teaching and learning are presented and the use of technology in education is outlined. The debate against the use of technology in education and how it has failed in the past is also presented. This was necessary because any use of new technologies in education will have to convince the critics that the emerging technologies will succeed when others have failed in the past. A case for the Internet in learning is presented with 11 reasons derived from research findings outlining why it should succeed. The problems associated with its implementation are also outlined.

In Chapter Four a review is presented of the current state of science in schools. Goodrum, Hackling, and Rennie (2001) produced a report titled *The Status and Quality of Teaching and Learning of Science in Australian Schools* which was very comprehensive and outlined the position of science education in Australia. This report together with various others are used to highlight issues such as the actual picture of science, the diminishing enrolments in science subjects and the widening gap in the achievement of boys and girls.

Chapters Five and Six outline the methodology of this research. The design and development of the WEBLEI is outlined in Chapter Five. The rationale behind each scale is discussed. The use of the modified version of the WEBLEI and the relevant amendments to the original version are highlighted. Chapter Six is an outline of the methodology adopted for the research for this study. The first section discusses the characteristics of a good website. The second section gives a detailed explanation on the design and features of *Getsmart* and how they relate to the cognitive apprenticeship framework. The research design is then explained in terms of the implementation of *Getsmart*, administration of questionnaires, data collection and analysis.

Chapters Seven to Twelve present and discuss the results of this study. In Chapter Seven, the findings of the WEBLEI projects an idea of students' perceptions across four scales – *Access, Interaction, Response,* and *Results.* This chapter also presents the reliability and validity statistics of the WEBLEI. In Chapter Eight, qualitative data gathered from emails, written surveys, and chats are presented. In doing so, it supports the data which was gathered quantitatively with WEBLEI.

In Chapter Nine, qualitative and quantitative results associated with the impact of a web-based learning environment on students' attitudes are presented. Quantitative data gathered using an *Attitude to Science* survey is presented together with a statistical analysis of the associations between the WEBLEI scales and this survey. This chapter also provides qualitative evidence gathered through written surveys and how it relates to the data gathered quantitatively. Students use of the website together with their online assessment of the lessons provides further evidence and demonstrates their positive attitudes towards this mode of teaching.

Chapters Ten and Eleven focus on the influence of a web-based learning environment on students' learning outcomes in senior physics and junior science respectively. In each chapter, qualitative data obtained from written surveys are presented. As in other chapters, evidence generated from quantitative data is used to support the evidence gathered through qualitative methods. In this case, quantitative data are generated from students' exam results. Chapter Twelve investigates the influence of web-based learning on boys and girls. The analysis focuses on their performance in exams before and after web-based learning. Comparisons are also made with the junior science cohort that completed their junior science studies the previous year.

Chapter Thirteen presents the findings associated with each research question together with some additional findings. The implications of this study for teachers is also reported. This chapter acknowledges some of the limitations of the investigation and recommendations for future research is also made.

1.9 CHAPTER SUMMARY

This chapter outlined the key aspects of this study. The background and the rationale of this research were initially explained. The research questions were then listed followed by the research methods that were used in this study. The significance and limitations of this study were also presented and an overview of this thesis summarised the key aspects of each chapter. The next three chapters which follow present literature reviews which are relevant to this study.

CHAPTER 2

CLASSROOM LEARNING ENVIRONMENTS

2.1 INTRODUCTION

Research has shown that the learning environment is an alterable educational variable which can directly influence cognitive and affective outcomes (Wang, Haertel, & Walberg, 1993; Waxman & Huang, 1998). It is not the only variable which affects learning outcomes; nonetheless, it is a very important one. By using various reliable instruments and a variety of qualitative methods, researchers have been able to assess the perceptions of educators and learners of their learning environments. This has enabled them to "theorise teaching and learning from different vantage points" (Tobin, 1998, p. 223).

The research described in this thesis examined the impact of an innovative web-based learning environment on students' perceptions to such an innovation and their attitudes and performance in junior science and senior physics. Perceptions and attitudes can influence learning outcomes. The field of learning environments has evolved through effective and quality research methods for more than three decades. In this study, the research into students' perceptions to their web-based environment and their attitudes and performance in science and physics relies heavily on the field of learning environment.

This review outlines historical perspectives of this field (2.2), looks at learning environment instruments and how these have evolved since the early versions were produced in 1960s (2.3), and demonstrates the versatility of recent findings of studies done in this field (2.4). These recent findings are also summarised in section 2.4. The learning environment instrument chosen for this research is described briefly in section 2.5. The last section presents a chapter summary.

2.2 HISTORICAL PERSPECTIVE

The goal of educational institutions is to optimize the learning outcomes of the learners. Educational programs are designed and implemented in the belief that the desired goals will be achieved. At the conclusion of any program developers and presenters both hope that the learners will demonstrate behaviours consistent with the desired outcomes. However, what does the learner think of all this?

A learner is constantly interacting with his or her learning environment. In 1930, Lewin proposed the Lewinian formula, B = f(P,E). This formula hypothesizes that human behaviour (B) is a function of the personal characteristics of an individual (P) and his or her environment (E) (Fraser, 1998a). This hypothesis has since generated considerable interest and formed the basis of further research in various situations where human behaviour is demonstrated. Since an individual is always interacting with his or her environment, observed behaviour is a result of the combined effect of the interaction between variables P and E.

In an educational setting, a learner is constantly interacting with an array of variables, such as teachers, peers, physical settings, subject materials and a cluster of factor(s) unique to different learner(s) (see Figure 2.1). Hence, there was a need to develop suitable learning environment instruments that had the capability of quantitatively measuring the impact of the learning environment on a learner.

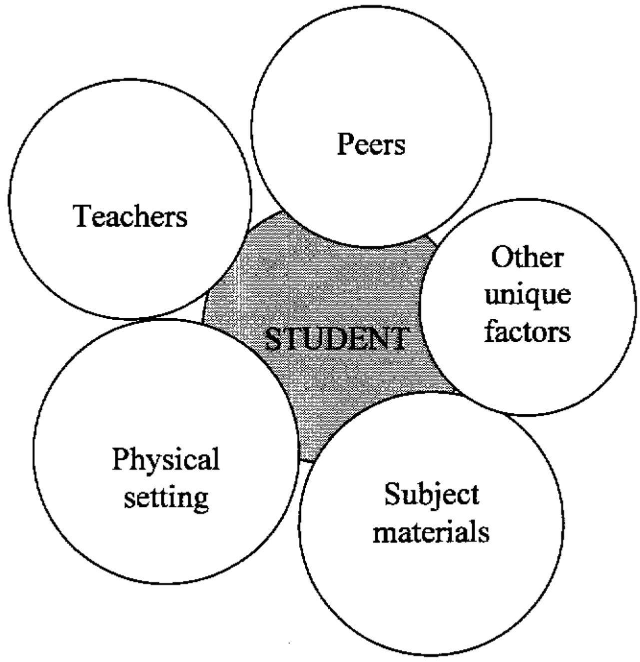


Figure 2.1. Variables in a student's learning environment.

The success of research initiatives in this field has relied heavily on the development of economical, reliable and valid learning environment instruments. In the past 30 years, much of emphasis has been placed on the development of reliable instruments to assess classroom environments from a student's perspective (Henderson & Fisher, 1998). The foundations for this now flourishing field of learning environments was initially laid by two psychologists who were working independently of each other: Herbert Walberg (1976) and Rudolf Moos (1974).

Moos (1974) developed social climate scales for use in hospital wards, juvenile and adult correctional facilities, residential care settings, therapeutic groups, sheltered workshops, work settings, families and classrooms. In designing these scales, he proposed that the characteristics of these diverse environments can be classified in terms of three dimensions (Walker, 2003; Waldrip & Fisher, 1998). Moos' three psychosocial dimensions were as follows:

- *Relationships Dimension* describes the relationship and the quality of interaction between individuals.
- *Personal Development Dimension* examines the extent to which an individuals personal growth and self-fulfillment are met.
- *System Maintenance and System Change Dimension* describes the extent to which the environment is orderly, clear in expectations, controlled and adaptable to change (Moos, 1974).

Walberg (1976) on the other hand "focussed on the notion that psychology is a science of mental life and that a key aspect of mental life is perception" (Kennedy & Dorman, 2002, p.1). Such a belief led Walberg (1976) to propose that participants such as students and teachers could quite successfully express their views on various aspects of their learning environments.

The work of Walberg (1976) and Moos (1974) led to the development of a variety of learning environment instruments. Each instrument was designed to quantitatively measure different variables within each dimension (Figure 2.2). The *Relationships Dimension* measured characteristics such as Friction, Satisfaction, and Involvement. The *Personal Development Dimension* measured variables such as Task Orientation, Integration, and Cooperation. The *System Maintenance and Change Dimensions* measured attributes such as Equity, Rule Clarity, and Teacher Control.

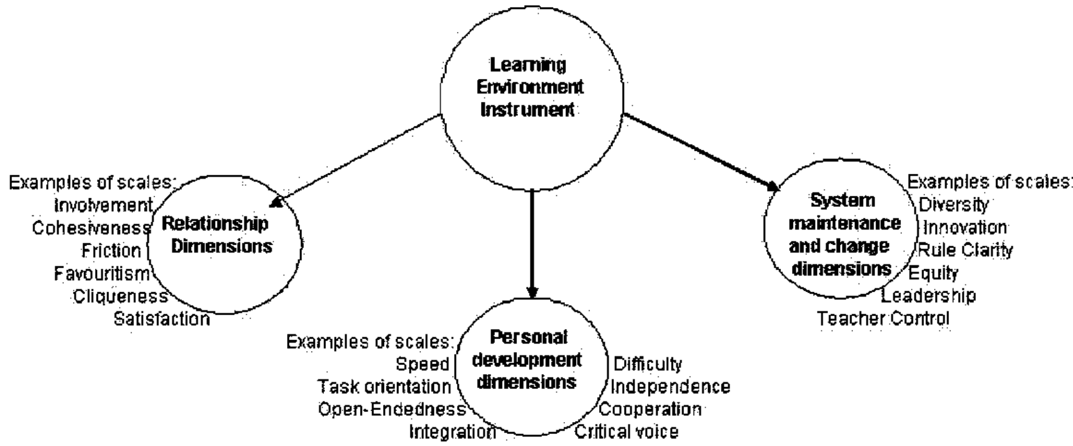


Figure 2.2. Learning Environment instruments and some of the scales measured within each dimension.

The use of learning environment instruments has not only painted a picture of students' perceptions of their learning environment, but it has been used to establish associations between numerous other variables such as achievement and attitudes (Fraser, 1998a). Majoribanks (1991) for instance, has shown how school and home environments collectively dictate individual academic achievement. The establishment of such relationships has been the result of the development and administration of quality learning environment instruments for use in different educational settings.

2.3 THE DEVELOPMENT AND USE OF LEARNING ENVIRONMENT QUESTIONNAIRES IN CLASSROOMS

Classrooms are different and the learning which occurs in them, is different. Hence, it is impossible to design a common learning instrument that would accurately assess all learning environments in every classroom. The evolution of learning environment research has depended heavily on the design and administration of a variety of reliable and economical learning instruments for different purposes.

While the variables measured by the learning environment instrument may have been different, the actual design has departed little from the design of the *Learning Environment Inventory* (LEI) (discussed in 2.3.1). Each instrument has a series of items clustered around scales that relate to Moos' scheme. Respondents are given a series of options to which they respond. Despite this relatively unchanged design, each instrument has nonetheless successfully fulfilled its purpose. Figure 2.3 is a time-line that shows the development of learning environment instruments since the Lewinian formula was first proposed. The development process has been analysed in ten-year blocks.

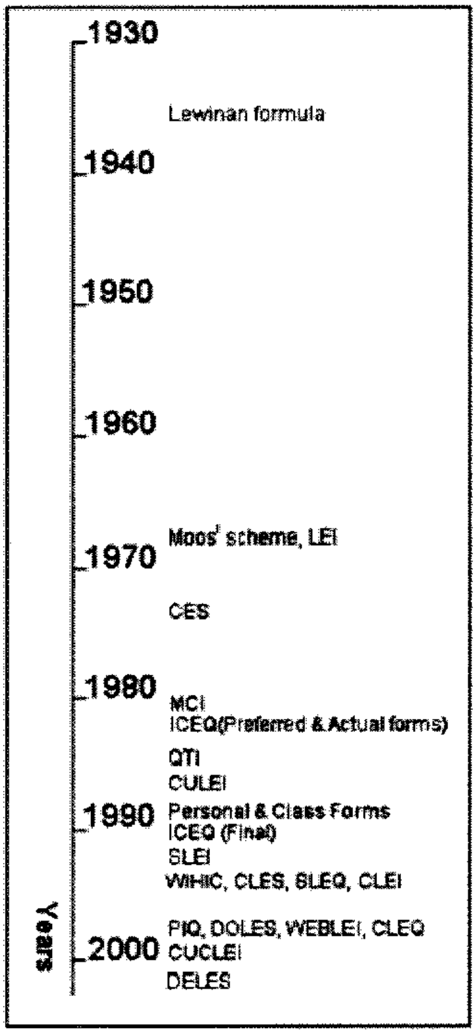


Figure 2.3. Timeline showing the development of key learning environment instruments.

2.3.1 Developments in the sixties

The findings of the Harvard Physics Project in the 60s were pivotal in the development and validation of the first learning environment instrument known as the *Learning Environment Inventory* (LEI) (Fraser, Anderson, & Walberg 1982; Walberg & Anderson, 1968). This instrument measured all three dimensions of the Moos scheme. Within the *Relationships Dimension* it contained six scales – Cohesiveness, Friction, Favouritism, Cliqueness, Satisfaction, and Apathy. In the *Personal Development Dimension,* it measured Speed, Difficulty, and Competitiveness. Within the *System Maintenance and Change Dimension* six scales were measured – Diversity, Formality, Material Environment, Goal Direction, Disorganization, and Democracy. In the final version, this instrument contained 105 items with seven items in each scale. Respondents had four options to each statement. The respondents strongly *agreed, agreed, disagreed,* or *strongly disagreed* with the statements. The scoring direction for some of the items was also reversed. The LEI was designed specifically for secondary students.

2.3.2 Developments in the seventies

The *Classroom Environment Scale* (CES) was the only significant instrument designed in the 70s (Moos & Trickett, 1974). Like the LEI, this instrument was also designed to assess the overall classroom environment. However, unlike the LEI, it had nine different scales with ten items in each with true or false response options.

2.3.3 Developments in the eighties

Fisher and Fraser developed the *My Class Inventory* (MCI) in the early 1980's (Fisher & Fraser, 1981; Fraser, 1998b) which was a modified version of the LEI. The primary reason for the modification was to enable this instrument to be used in primary schools. Unlike the LEI, it only had five scales (Satisfaction, Friction, Competitiveness, Difficulty and Cohesiveness) and the items were modified to enhance readability. Instead of four responses, the MCI items had *yes* and *no* response options. It also enabled respondents to answer on the questionnaire itself. For instance, *Schoolwork is hard to do* and *Some pupils don't like my class* were two of the five items in the Difficulty scale. The simplicity of the statements not only enhanced its suitability for the primary school clientele, but the presence of yes and no response options made it more user-friendly. This work of Fisher and Fraser was significant in the field of learning environments research because it showed that learning environment instruments can be modified to suit different classrooms. Since this initial modification, the MCI has been used for junior secondary students. It also been further modified by various researchers both in the number of items and in the response format which further demonstrates the versatility of this instrument.

Rentoul and Fraser (1979), in order to distinguish between individualised and conventional classrooms, developed the initial version of *Individualized Classroom Environment Questionnaire* (ICEQ). Eleven years later the final version was developed (Fraser, 1990). The final version of the ICEQ has 50 items that measured five scales with ten items and five response options in each. The time taken in producing the final version is a reflection of almost all learning environment instruments which were refined and developed through research findings before the final version was published.

Moos (1974) suggested that participants usually perceived their actual setting less favourably than the preferred setting. To explore this suggestion further, Fraser and Fisher created an *actual* and a *preferred* learning version of the ICEQ to gather data on students' perceptions of their learning environment (Fraser & Fisher, 1983). In the actual version students responded to items as they related to their actual environment. In the preferred version they responded to the same items in terms of what they would like or prefer their environments to be. A similar set of forms or questionnaires were also administered to teachers with minor modifications in the wording of each item. Information from such surveys gave teachers an opportunity to re-evaluate and improve their classroom learning environments in order to fulfill student expectations. Numerous studies carried out on actual and preferred environments produced two resounding results (Fraser, 1998b). Firstly, students generally scored the scales higher for their preferred learning environment than the actual environment. Secondly, the teachers tended to perceive a more positive classroom environment than their students.

Researchers, Wubbels, Crèton, and Hooymayers (1985), developed the *Questionnaire of Teacher Interaction* (QTI) originally in the 80s. The primary aim of this instrument was to ascertain perceptions of the relationship between teachers and learners in educational institutions. Since its initial design, a more economical version with 48 items has been produced which has been cross-validated and used in comparative studies in various countries (Fisher, Fraser, & Wubbels, 1993; Fisher, Rickards, & Fraser, 1996). The design of the QTI gave an insight into an unexplored aspect of the modern classroom environment.

2.3.4 Developments in the nineties and beyond

One of the obvious trends in the timeline shown in Figure 2.3 is that from 1990 onwards there was much more research and development of learning environment instruments. The MCI was useful in primary and junior secondary classrooms and the LEI was useful in secondary school classrooms. However, there were no quality learning environment instruments that could effectively give an accurate picture of a university classroom. The *College and University Classroom Environment Inventory* (CUCEI) was developed for this purpose (Fraser & Treagust, 1986). A modified form of the CUCEI was produced late in the nineties with seven, seven-item scales and four response options (Nair & Fisher, 1999).

In the early nineties, researchers like Fraser and Tobin (1991) realized the need for *personal* and *class* forms. They argued that a respondent's opinion on items such as *The work of this class is too difficult* may be different from *I find the work of the class difficult* (Fraser, 1998b, p. 16). Hence, the personal form enabled respondents to give an indication of how the learning environments affected them personally. The class form on the other hand gave them an opportunity to express their views on the class as a whole.

The science laboratory plays a very important role in the lives of high school students, therefore, the *Science Learning Environment Instrument* (SLEI) was developed to ascertain students' perceptions of a science laboratory (Fraser, Giddings, & McRobbie, 1993). The SLEQ measured students' perceptions across five scales, each with seven items. Each item had five response options and the instrument was validated and then cross-validated with the data gathered from a large sample of students who lived in seven countries (Fraser, 1998b).

Through the efforts of pioneering researchers like Fraser, Fisher, Moos, Walberg, and Wubbels, by the mid-nineties research in the field of classroom learning environments was firmly established. There was significantly more confidence amongst researchers to expand this field in other novel ways.

The *What Is Happening In This Classroom* (WIHIC) was developed by Fraser, Fisher, and McRobbie (1996) by combining the most salient scales from a wide range of existing questionnaires (Fraser, 1998b). The final form with seven eight-items scales was developed as a result of research findings from Taiwan, Singapore and Australia (Fraser, 1998b).

Other studies focused on identifying attributes of special classrooms. The *Constructivist Learning Environment Survey* (CLES) was developed to ascertain the extent to which a constructivist classroom was consistent with a constructivist epistemology (Fraser, 1998b; Taylor, Fraser, & Fisher, 1997). Fisher and Waldrip (1997) developed a 40-item *Cultural Learning Environment Questionnaire* to assess culturally sensitive factors of learning environments.

A number of studies conducted have used modified versions of surveys developed earlier. For instance, Newby and Fisher (1997) modified the Science Laboratory Environment Inventory (SLEI) and created the *Computer Learning Environment Inventory* (CLEI). While the SLEI measured scales associated with Student Cohesiveness, Open-Endedness, Integration, Rule Clarity, and Material Environment, the CLEI also measures each of these scales except Rule Clarity which was replaced by Technology Adequacy. Similarly, Henderson, Fisher, and Fraser (1998) modified the SLEI and created the *Environmental Science Learning Environment Instrument* (ESLEI) which measured Student Cohesiveness, Integration, Material Environment, Involvement, and Task Orientation.

Learning environment instruments have also been developed and used in a variety of situations outside the classroom. The *School-Level Environment Questionnaire*

(SLEQ) developed by Fisher and Fraser (1991) is an example of an instrument that was used to evaluate teacher perceptions beyond individual classrooms. Since one of the factors which can affect the productivity of schools, is the relationship between teachers and principals, Fisher and Creswell (1997), developed the *Principal Interaction Questionnaire* (PIQ) to assess the characteristics of this relationship.

Distance education is an important part of teaching. In recent times as the Internet became more accessible, interest in this mode of study also has increased. The *Distance and Open Learning Environment Scale* (DOLES) was developed with five core and two optional scales and was used to gauge the views of university students studying in this mode (Jegede, Fraser, & Fisher, 1995). The *Web-based Learning Environment Instrument* (WEBLEI) was developed to establish students' perceptions of web-based learning environments in tertiary settings (Chang & Fisher, 1998). The learning environment questionnaire used in this research was modified from the WEBLEI. The design and the development of this instrument is discussed further in section 2.5 and in Chapter 5. Recently, the *Distance Education Learning Environments Survey* (DELES) has been developed with six psychosocial environment scales and one attitudinal scale (Walker, 2003).

2.3.5 Common statistical methods used in data analysis

A range of statistical techniques has been used to quantitatively analyse the data obtained from surveys conducted using the learning environment instruments. The magnitude of the *Cronbach alpha reliability* coefficient gives an indication of how consistently students respond to each item within each scale. An alpha reliability of 0.60 or greater is considered to be acceptable (Nunnally, 1967). Fraser (1998b) reviewed a number of learning environment instruments (LEI, CES, ICEQ, MCI, CUCEI, QTI, SLEI, CLES, WIHIC) which have been discussed in earlier sections. Apart from the LEI and the CES (two of the earliest instruments), all the others have an alpha reliability of more than 0.60 which reflects the quality of these instruments. Other surveys also had alpha reliabilities in the acceptable range for instance; the WEBLEI (0.65 to 0.88) (Chang & Fisher, 1998), the DELES (0.75 to 0.95) (Walker, 2003), the ELSEI (0.69 to 0.77) (Henderson, Fisher, & Fraser, 1998), the CUCEI

(0.73 to 0.94) (Nair & Fisher, 1999) and the CLEQ (0.69 to 0.86) (Waldrip & Fisher, 1998).

Another common statistical measurement is the discriminant validity which is expressed as the mean correlation of one scale with all the others, in the same instrument. This measurement gives an idea of the extent to which a scale measures a unique facet not covered by the other scales in the instrument. In all the cases discussed above, the instruments appear to measure distinct, although somewhat overlapping aspects of the learning environments, because in every study the mean correlation between the scales was small.

Since the internal consistency and reliability measurements for each instrument requires a large number of students in different classes, single ANOVA (eta^2 statistic) measurements can be calculated to determine the extent to which the perceptions of students in different classrooms vary. The eta^2 statistic gives an indication of the proportion or percentage of the variance in the dependent measure that is related to the independent variable (Tilley, 1999). Single ANOVA values in some of the studies discussed above range from 0.09-0.28 using the CUCEI (Nair & Fisher, 1999), 0.08-0.13 using the CLEQ (Waldrip & Fisher, 1998), 0.18-0.43 using the CES, 0.20–0.43 using the ICEQ, 0.18- 0.30 using the MCI (Fraser, 1998b). All the values determined were significant at the 0.01 or 0.001 level. These values were relatively low which suggests that the variation in student perceptions in different classes was small.

2.4 RESEARCH INTO CLASSROOM LEARNING ENVIRONMENTS

Since the initial development and application of the Learning Environment Inventory (LEI), research in the field of learning environment has thrived and has been applied to many disciplines of study and in different situations. Research in this field has since taken a two-pronged approach. While the use of learning environment instruments plays a dominant role, quantitative methods are also used either in conjunction with qualitative methods or on its own. Qualitative methods such as interviews and lesson observations capture other aspects of the study, thus enhancing the quality of the research. Data generated from a combination of qualitative and quantitative methods present a better understanding of learning environments (Fraser, 1998a). Additionally, with such a combination, the disadvantage of one method is offset by the strengths of the other which in turns enhances the quality of the research (Jayaratne & Stewart, 1995).

The focus of this study was to investigate the impact of a web-based learning environment on students studying science and physics at a high school. Hence, this section discusses the findings of recent studies relevant to this research that support the idea of adding variety to existing lesson delivery methods. These investigations and their findings are also considered in light of why a switch to a web-based learning environment has the potential to improve students' perceptions of their respective learning environments. Research into learning environments is counterproductive unless appropriate steps are taken to eliminate factors which lower student's perceptions.

2.4.1 Research focused on different levels of schooling

Waxman and Huang (1998) used shortened versions of the CES and the *Instructional Learning Environment Questionnaire* (ILEQ) with 7,075 elementary, 4,286 middle and 2,141 high school students in the south central region of the USA. They reported that students in the middle school perceived their classroom learning environments less favourably than those in elementary and high school. Girls perceived their environments more favourably than boys. Interestingly the alpha reliability of five out of the eight scales measured ranged from 0.41 to 0.59 which was below 0.60, the acceptable value proposed by Nunnally (1967). The researchers pointed out that up to 50% of the participants were "at risk" due to their poor performance in school. Perhaps the inability of the group to interpret the items of the ILEQ may have led to the low alpha reliabilities.

In the Queensland context, middle schooling equates to Years Four to Ten. Education Queensland publication, *Education Views* emphasised the importance of middle schooling. According to the publication " Recent studies have shown that this is a time when these young people lose their enthusiasm for learning, disengage from classroom activities and make the least progress in learning" (*The middle phase of* *learning*, 2003, p. 12). Unfavourable perceptions of their learning environments at this stage of students' lives can significantly influence how they view schooling in the years that follow. Hence, it is important to ensure that the characteristics diminish students' perceptions of their learning environments, should be identified and appropriate measures must be taken to reverse any negative beliefs. Perhaps a change in teaching and learning pedagogies could transform such classrooms by creating an environment that was preferred by both sexes. An innovative approach may help diminish the gap between the academic performance of boys and girls.

Working with lower primary students, Kuklinski and Weinstein (2000, p. 1) observed that in classrooms where high achievers were favoured over lower achievers, there was a "heightened risk of teacher expectancy effects and other maladaptive outcomes". This risk was reduced in classrooms where high and low achievers were treated "more equitably in the eyes of the children." In many classrooms, while teachers may not necessarily favour high achievers, over time students tend to develop such perceptions. This may be due to the frequent interactions between teachers and high ability students because they engage in classroom interactions to a far greater extent than other students. Nonetheless, such perceptions should be eliminated from learning environments. In a web-based learning environment, students have the opportunity to interact on a one to one basis and there is no favouritism. In this situation, all students are treated equally.

2.4.2 Research focused on maths and science classrooms

While the focus of this research was on science, the research carried out in both maths and science classrooms are discussed in this section because the two subjects usually go hand in hand. While conducting interviews of eighth-grade physical science students at a school in Illinois (USA), Lorsbach and Basolo (1998, p. 125) reported that the students perceived science as "a body of facts to be learned and less a social process". They did not see it as a subject which had an enquiry or problem solving approach. While the students had technological interests, experimentation was viewed as a case of regurgitating what others had already found out. Perhaps, the finding of Lorsbach and Basolo (1998) reflects the perceptions of students in many junior science classrooms today. It is negative perceptions such as these that have to be overcome in order to improve the appalling picture of science (see Chapter Four). A properly designed website with lessons, tests, links to related websites and interactive activities has an enormous potential to reverse such beliefs.

In one cross-cultural study, Aldridge and Fraser (2000) used the WIHIC and found that while Australian students in junior secondary school perceived their classrooms more positively, students of a similar age group in Taiwan had a more positive attitude to science. Through interviews, observations, and narrative stories, they suggested that the variation in findings was largely a result of the curriculum in each country, for instance in Taiwan, the curriculum was "exam driven". Another important reason for the variation was probably due to the sample used. The Taiwanese sample included students who were studying biology and physics whereas the Australian sample included students who were studying junior science. The former probably chose biology and physics voluntarily which explains the more positive attitude to science, whereas the latter were taking science probably because it was compulsory. Aldridge and Fraser (2000) also reported that the degree of respect that students held for their teachers affected the classroom environment.

In research which involved eleventh-grade chemistry students in Israel, it was found that students engaged in enquiry-type laboratory activities (enquiry group) had more positive perceptions to the Open-endedness and Involvement scales of the SLEI than their counterparts in a control group (Hofstein, Nahum, & Shore, 2001). The researchers also found that for the enquiry group, the gap between the students' perceptions of their actual and preferred environments was smaller than those for students in the control group. Hofstein, Nahum, and Shore (2001) pointed out that the students involved in the enquiry approach to learning formulated their own answers rather than relying exclusively on textbooks and teachers. Their research also showed that carefully designed learning activities with varied presentation approaches could influence students' perceptions of their learning environment.

In another study in Israel, the senior chemistry course was modified by incorporating industrial chemistry as a teaching unit. The industrial chemistry component highlighted actual situations. The course was supplemented through initiatives such as project work, excursions, and use of print media (Hofstein, Kesner, & Ben-Zvi, 1999). By administering the *Chemistry Classroom Learning Environment Inventory* (CCLEI) to the participants, it was found that there was no difference in the perceptions of boys and girls in terms of their classroom environments. Through qualitative methods, the researchers concluded that such initiatives helped make the chemistry classroom more relevant. As in the previous study, Hofstein, Kesner, and Ben-Zvi (1999) varied their teaching routines and in doing so, they made their subject more appealing to both boys and girls. Such desirable changes address the issues associated with science education and are discussed in detail in Chapter 4. Likewise, the inclusion of web-based learning in normal teaching programs creates a break in the routine. It also gives students an opportunity to "travel" beyond the boundaries of the classroom and interact with "virtual reality" on the World Wide Web.

Majeed, Fraser, and Aldridge (2002) explored the perceptions of lower secondary mathematics students in Brunei Darussalam. Using the MCI, they reported that boys perceived the mathematics classroom environment more favourably than did girls. Their research supported the findings of earlier researchers such as Henderson, Fisher, and Fraser (1995) and Wong and Fraser (1994). These findings are useful and pave the way for improvements in the classroom climate.

2.4.3 Research focused on technology based environments

Tobin (1998) investigated the perceptions of practising teachers involved in a distance learning program taught via the Internet. He used a qualitative hermeneutic approach in which he considered students' values, priorities, and needs to be paramount when defining the variables of the learning environment. He concluded that there were 15 categories that the learners thought were important in defining an online learning environment. He grouped these categories in three dimensions which fitted in with the initial definition of the learning environment by Moos (1974). Tobin's work formed the basis of the formulation of the WEBLEI, the learning environment instrument that was modified and used in this study.

The *Connecting Communities of Learning* (CCL) program was developed by Tobin (1998) for the delivery of graduate course in science and mathematics education. This facility enabled the transmission of text between the learner and the teacher through options such as *Notice Boards, Mail Room, DJs, Critical Reviews,* and the *Conference Centre*. Goh and Tobin (1999) found that the three dimensions identified by Tobin (1998) namely autonomy, co-participation, and qualia were significant dimensions that were closely associated with the CCL. They also reported that students who were enrolled in courses which did not use CCL worked harder. Goh and Tobin (1998) expressed the need for the development of a suitable learning environment instrument that would satisfactorily investigate the effectiveness of web-based learning environments. They used a qualitative approach and reported that while the learning environment was richer and the learning was enhanced, the costs also appeared to be higher. Nevertheless, the Internet today has become more affordable than it has ever been in the past.

The integration of technology into classrooms does not always guarantee an improvement or reversal of student perceptions. Hartwell, Gunter, Montgomery, Shelton, and West (2001), for instance, used the CLES, to observe the effect of the integration of technology in grade six mathematics and science classes. They reported that with their sample this initiative did not produce any significant statistical change in any of the scales measured. For researchers, it is even worse when the effect is negative to what was initially anticipated when innovative initiatives are introduced in classrooms. Elen and Clarebout (2001, p. 87) investigated the implementation of an "ill-structured innovation' on students "instructional and epistemological beliefs". They reported that in an innovative project, when high school students were given the opportunity to work collaboratively on a problem based, authentic task in a technologically-rich learning environment, the outcomes were negative and least expected. This finding suggests that while innovative teaching methods are welcome, the changes should not be extreme. Elen and Clarebout (2001) warned that an innovation could be detrimental to learning if a very new environment confronts teachers and learners. For this reason, innovative teaching methods should be introduced gradually into learning environments. This presents a case for the implementation of web-based learning in a blended approach in a high school environment.

It is also important to note that innovations should mirror the real abilities of students. Research in educational psychology suggests that the brain learns best when the context provides a moderate challenge. However, if the task is too difficult, the learner "down shifts into a self-protection mode" and if the task is too simple the learners thinking and problem solving ability diminishes and he or she drifts into a "relaxation mode" (Tomlinson, 1993, p. 42).

The *Networked Interaction: Theory-Based Cases in Teaching and Learning* (NINTER) project was developed in Finland for students enrolled in an Internet based university course. It was designed on the principles of socio-constructivist learning theories. The aim of this project was to produce a model for teaching and learning in online environments (Saarenkunnas, Järvelä, Häkkinen, Kuure, Taalas, & Kunelius, 2000). Interim findings of this project suggested that such an approach appeared to enhance learning and promoted deeper understanding. The researchers also found that the flexible use of different learning technologies proved to be fruitful.

Newby and Fisher (1997, 2000) used the CLEI and the *Attitude towards Computing and Computer Courses* (ACCC) to assess the relationship between computer laboratory environment and student outcomes. Students from a Business school of a university were involved in this study. The study showed that while there was little association between these two variables (computer laboratory environment and student outcomes), there was an indirect association between them through the attitude variable. It was found that a positive perception of the Usefulness of computers scale led to the Enjoyment of computers which in turn reduced Anxiety.

As laptops become more affordable, more students are likely to use them as part of their learning. At present, laptop computers have been used in some schools and their uses vary from one classroom to the next. Newhouse (2001) used the *New Classroom Environment Instrument* (NCEI) and interviews to ascertain the perceptions of lower secondary students who had access to a laptop. In the classrooms, the use of these computers varied from some use such as "writing reports and notes" to "not used at all" (Newhouse, 2001). He administered the survey at different times and observed that in classes where laptops were used, the environments were seen to be more innovative and involving. There appeared to be little change in the learning environments where the instruction was wholly teacher-driven and no computers were used during lessons. Such a finding is important because it shows that any meaningful change in the classroom routine may produce a significant gain in students' perceptions of their learning environments. A shift from a passive to an active mode of learning also has the potential to generate desirable outcomes.

Gräsel, Fischer, and Mandl (2000) studied the impact of computer-based self-directed learning in 'problem-oriented' learning environments with fourth year medical students. They concluded that even with advanced learners, "instructional designers cannot rely on learners recognizing and correcting their mistakes when learning individually" (Gräsel, Fischer, & Mandl, 2000, p. 302). If academically capable students have these problems, then obviously at lower levels of education such problems could be a bigger issue. It depends on how these online learning environments are developed. Nevertheless, this finding appears to support a blended approach to web-based learning. In such situations a learner is not left on his or her own all the time. When problems arise, he or she can interact with peers or the instructor face to face to resolve problems. The teacher or the instructor can also provide scaffolding as the need arises. Gräsel, Fischer, and Mandl (2000) also pointed out that excessive use of hypertext systems did not support learners as much as they were supposed to, suggesting that websites should encompass features that are useable and user friendly.

Khine (2003) developed a CD-ROM for delivering a module of a teacher education course in a tertiary environment in Singapore. The CD-ROM was designed in a web-format and was capable of interfacing with a variety of multimedia resources such as video clips and the *Blackboard* communication tools. He reported that most students had positive perceptions of their learning environments and he went onto suggest that such an approach could be used in teacher education. Aldridge and Fraser (2003) developed the *Technology-Rich Outcomes-Focussed Learning Environment Inventory* (TROFLEI) to ascertain students' perceptions of their technology-rich learning environment in an Australian high school. They conducted their study over two years and found that students not only had positive perceptions across all ten scales of TROFLEI, but also had positive attitudes towards their subject, computer use and academic efficacy. Similar findings were reported by She and Fisher (2003), who researched the impact of web-based learning on teaching water pressure in science lessons using *Macromedia Flash* in Taiwan. Results gathered using the WIHIC, suggested that students had positive perceptions towards this learning environment and across various attitudinal scales (She & Fisher, 2003).

The findings of a research project which involved tertiary students in Hong Kong led Trinidad (2003, p. 110) to suggest that in technology-rich environments the learners had

> …a sense of empowerment, where they are no longer dependent on the specific and often limited knowledge of their educator, but work within a community of learners who can participate in the process of pedagogical change that involves practical applications of new materials, new methods and new beliefs.

Trinidad (2003) also pointed out such practices produced a shift from teaching to learning. Working with chemistry teachers in Israel, Kesner, Frailich, and Hofstein (2003), concluded that there was significant push in science education to produce scientifically literate students. For this to occur, there was a need for the development of classrooms that addressed the needs of different learners. They suggested that the Internet had a significant potential to produce variety in the classroom environment and thus address these needs (Kesner, Frailich, & Hofstein, 2003).

2.4.4 Research focused on special issues

Hong (2001) investigated the homework **styles** of more than 270 seventh grade students and reported that students who scored high on homework style were persistent, responsible, preferred structure and order, and worked alone. Their motivation was from their teacher, parent or from within. Five of these qualities: self-motivation, teacher motivation, structure, persistence, and working alone were the actual style components of those who achieved distinguished results in mathematics. The findings in this instance by Hong (2001) suggests that if opportunities were created for students to work outside school, then learning outcomes were more likely to improve. Classroom teachers are generally restricted in this regard unless students are motivated from within and they undertake the homework that is set for them. A web-learning environment on the other hand has the potential to create such an opportunity outside school hours.

In an interesting study involving seating arrangement and question asking patterns, it was found that students' "question-asking comfort" was dependent upon multiple demographic, social, and personal factors and was influenced by perceived teacher support and the complexity of questions (Marx, Fuhrer, & Hartig, 1999). The researchers believed that there was a statistical significance between student's seating location and question-asking behaviour. The research of Marx, Fuhrer, and Hartig (1999) raises two issues that support web-based learning. Firstly, students who are not at ease in their question-asking comfort zones will lag behind in normal classroom situations. The Internet on the other hand creates alternative opportunities through emails, chat rooms, active interaction and discussion boards where some of the deficiencies can be overcome. Secondly, if seating location influences question-asking behaviour, then in every classroom there will always be at least some students who either have chosen or have been allocated seats that impinge on their interaction through questions. If this is a significant issue, then a web-based environment guarantees that no student will be disadvantaged in terms of where they sit when they engage in learning.

2.4.5 Research on teaching and learning methods

For students to engage in learning, teachers should create learning environments in which students' feelings are considered, individual interaction with students occurs, and students are helped whenever necessary (Dart, Burnett, Gillian, Campbell, Smith, & McCrindle, 1999). Dart et al. (1999) also suggested that teachers should create learning experiences that make students to be actively involved in the construction of meaning. The teachers should also ensure that students know, understand, and can apply investigative strategies that facilitate problem solving. These findings were based on a study in which the *Learning Process Questionnaire,* the ICEQ and the *Learner Self Concept* were used with high school students. Dart et al. (1999) also suggested that such an approach would not only promote deep approach to learning but it would also enhance the self-concept of the learners.

Dart et al. (1999) described a deep approach to learning as constructivist teaching in which the intention is to seek meaning and understanding through "elaborating and transforming the material" that was being studied. This was opposite to the surface learning approach that related to the transmission of knowledge to learners where they assumed passive roles and merely regurgitated information; the achieving approach of learning was linked to both the deep and surface approach (Dart et al., 1999). They also observed that there was little difference between learning environments and learning approaches when applied to either gender or level of schooling. Additionally, they reported that while in a normal classroom, surface and deep learning occurred interchangeably, low ability and unmotivated learners had difficulties at times switching from one mode to the next. A web-based learning environment could offer flexibility and enable learners to choose their learning materials when they were ready. It also has the potential to address Sarason's concerns (1993) about the one-size fits all delivery approach which does not necessarily do justice to all learners.

Park (2001) explored the importance of learning styles (auditory, visual, kinaesthetic, and tactile) on the preferred learning styles of students from different ethnic backgrounds in high school environments. Park believed there was a relationship between ethnic origins and gender with learning styles and achievement levels. If learning styles and achievement levels depend on gender and ethnic origins, then in a multicultural society like Australia, numerous teaching methods must be applied in classrooms to effectively reach all learners.

Maor (1999) designed and administered the *Constructivist Multimedia Learning Environment Survey* (CMLES) in a professional development program. An interactive multimedia program (*Birds of Antarctica*) was used with teachers to develop their understanding of constructivist epistemology. Through the analysis of the survey data, Maor reported that the teachers perceived such an environment as one that provided more opportunities for social interaction and student negotiation of their learning. They also found it to be both complex and authentic.

Many studies on learning environments have investigated the characteristics of the actual classroom environments. Very few investigations have explored the significance of interventions on these environments (Fraser, 1994). McRobbie and Thomas (2000) investigated the impact of such interventions on senior chemistry students. They reported that because of interventions, student results in different parts of their examinations improved. Such an approach is vital as it enables the identification of strengths and weakness in the teaching methods used during interventions.

While research into learning environments has flourished, not all researchers agree with the theory or the instruments developed as a result of it. Roth (1999) pointed out that the learning environments research is based on an assumption that something like an environment independent of the individual can be identified. He also pointed out that research in many disciplines questions this assumption. Roth (1999) suggested that it is possible to theorise learning environments as an integral part of learners. On the other hand, Jensen (1998) pointed out that 40 to 70% of the *brain wiring* was the result of environmental impact. Educational psychologists such as Piaget and Vygotsky have also emphasized the importance of experience in the learning process (McInerney & McInerney, 2002).

Ideas such as those suggested by Jensen (1998), Piaget and Vygotsky (McInerney & McInerney, 2002) lead to a view that the learning environment, in which a learner is immersed, plays an important part in the learning process. Thus, Roth's (1999) suggestion that the learning environment was an integral part of the learner and his doubts about its existence independent of the individual needs a closer examination. While there may be some truth in his belief that learning environments are an integral part of the learner, on the other hand many experiences in the learning environments are created by forces that are well beyond the individual. In a classroom, students can create their own learning environments, but in many instances, the environment that they create is dependent upon forces that are beyond their control (e.g., the teacher, the physical environment, and other students in the classroom). Consequently, to assume that all learning environments are an integral part of the learner may be inaccurate assumption that swings the pendulum back in favour of the existing theories of learning environments.

2.5 SELECTION OF A LEARNING ENVIRONMENT INSTRUMENT FOR THIS STUDY

Following consideration of all the learning environment instruments available, it was decided to modify and use the WEBLEI (Chang & Fisher, 1998). The WEBLEI measures student perceptions on four inter-related scales namely, Access, Interaction, Response, and Results. The WEBLEI is currently the only learning environment instrument which has the capability of assessing the effectiveness of a web-based learning environment. A more detailed discussion on the development of this instrument and justification of its use is presented in Chapter Five.

2.6 CHAPTER SUMMARY

One of the aspects of this research is to address the impact of web-based learning (in a blended learning environment) on the perceptions, attitudes, and performance of boys and girls in junior science and senior physics. In the literature review, (section 2.4) web-based learning was shown to have the potential to address the findings of numerous investigations. For instance, by providing a uniform teaching medium blended with traditional teaching, web-based learning minimizes the impact of factors, such as a child's seating position in class (Marx, Fuhrer, & Hartig, 1999) or teacher bias in classrooms (Kuklinski & Weinstein, 2000).

The web-based approach also caters for a variety of learning styles (Park, 2001). *Getsmart* (the website designed specifically for this research) was embedded with some of the qualities identified by Hong (2001) that can influence learning outcomes. Such an approach also addresses other concerns. For instance, science is viewed as a body of facts to be learned and less of a social process which did not have a problem solving, or enquiry approach (Lorsbach & Basolo, 1998). Changing the way science is taught has the potential to make some changes to this perception (Hofstein, Kesner, & Ben-Zvi, 1999; Hofstein, Nahum, & Shore, 2001). The impact of a web-based learning environment in this instance can be explored in a high school setting.

Do the boys and girls perceive their learning environments differently? Studies done so far (e.g., Hofstein, Kesner, & Ben-Zvi, 1999; Majeed, Fraser, & Aldridge, 2002; Waxman & Huang, 1998) suggest that there could be a difference or none at all. However, as Creemers and Reezigt (1999) pointed out, research findings could vary from one situation to the next. Hence, the impact of a web-based learning environment on gender is yet to be fully understood.

Students in the middle school perceived their classroom learning environments less favourably than those in elementary and high school (Waxman & Huang, 1998). How does a web-based learning environment impact on students in different year levels and subjects?

Computer-based learning is different from e-learning or Internet-enabled learning. Research driven by both these technologies has so far produced findings which are conflicting. Some studies have reported positive findings in terms of learning outcomes, perceptions, or attitudes (e.g., Goh & Tobin, 1999; Maor, 1999; Newhouse, 2001; She & Fisher, 2003; Saarenkunnas, Järvelä, Häkkinen, Kuure, Taalas, & Kunelius, 2000) while others have reported little or no change because of the introduction of these technologies (e.g., Hartwell, Gunter, Montgomery, Shelton, & West, 2001; Newby & Fisher, 1997, 2000). In this study, this relationship is explored once again but in a unique situation.

This study takes into account three earlier studies. Firstly, it uses the findings of Gräsel, Fischer & Mandl (2000) who studied the impact of computer-based self-directed learning in problem-oriented learning environment and concluded that even with advanced learners, "instructional designers cannot rely on learners recognizing and correcting their mistakes when learning individually" (p. 302). Consequently, this study takes a blended approach where web-based learning occurs in conjunction with traditional teaching. Secondly, it takes into account the findings of Elen & Clarebout (2001) who researched on the implementation of an ill-structured innovation on students' instructional and epistemological beliefs. They warned that an innovation could be detrimental if teachers and learners were confronted by a totally new environment. For this reason, in this study web-based learning was introduced in small packets and in a blended environment.

Thirdly, the design of the website takes into account the findings of Dart et al. (1999) who pointed out that for students to engage in their learning, teachers should create learning environments in which students feelings are considered and individual interaction with students occurs. They believed that students should also be helped whenever necessary and the teacher should create learning experiences that require students to be actively involved in the construction of meaning, ensuring that students know, understand, and can appropriately apply investigative strategies to facilitate problem solving (Dart et al., 1999). The design of *Getsmart* takes many of these ideas into consideration.

The use of the Internet has offered hope to many educators across the globe. The results of many learning environment studies have supported this view (e.g., Aldridge & Fraser, 2003; Kesner, Frailich, & Hofstein, 2003; She & Fisher, 2003; Trinidad, 2003). While such studies paint a glossy picture in terms of how the incorporation of technology in the classrooms can influence learning outcomes, such views and conclusions have also been drawn in the past with other products of "new" technologies such as television, radio, and video players. Despite the high levels of optimism offered by technology options, classrooms for most of the students of the last century have changed little. Chapter Three explores the impact of technology in the classroom and it presents a case why the Internet is more likely to succeed in the present educational climate.

CHAPTER 3

TECHNOLOGY IN LEARNING

3.1 INTRODUCTION

Technological advances in the past decade have created teaching and learning opportunities of significant proportions that would have been a fantasy a few years ago (Dierker, 1995). Ralph Gomory (President of the Sloan Foundation in America) summed up the effect of this transformation as follows:

> History likes to dwell on people who were self-educated, they learned on their own from a few books, struggled through snowstorms to the public library, or in a later epoch and on a larger scale, struggled through daytime jobs and then went year after year to night school. We don't hear about those who wanted to learn but couldn't because they chose not to take time from their caring families, or because there simply were no night schools where they were…today...learning can be done at a time and place of your choosing…by making learning outside the classroom less heroic, we can make it what it ought to be, an ongoing part of ordinary life.
>
> (2001, p. 145)

In the past few years, there has been a significant investment into the acquisition of Information and Communication Technologies (ICT) by educational institutions worldwide. There are various reasons, which explain such a trend. For instance, the rationale for such investment lies in the belief that ICT are essential for the creation of internationally competitive economies (Rickards, 2003). Rickards also pointed out that giving young people an opportunity to interact with ICT enabled them to think creatively and develop problem-solving skills for the future. Another significant factor is that many young people today have grown up with multimedia (McInerney & McInerney, 2002) and the new technologies "speak their language". According to Eklund, Kay, and Lynch (2003) many students in Australian Schools, were more skilled in using computers than their teachers. Consequently, the incorporation of ICT in education gives hope of creating an environment which is probably more conducive to learning than in traditional settings.

> Many argue that the traditional educational tools (the teacher and soft technology such as books) are not sufficiently motivating for today's learners, who are accustomed to the pace of electronic entertainment and instant access to information. Nor can traditional teaching approaches provide the challenges and consistent success experiences that computer programs profess to...
>
> (McInerney & McInerney, 2002, p. 164)

Consequently, educators have been searching for novel methods to incorporate the Internet as part of their teaching routines. Bain (as cited in Barker, 2001, para. 8-10), an educator at the Brewster Academy in the USA described the application of e-learning and the Internet as follows:

> We are building technology now that not only allows the teacher to do a better job, but that lets kids come in and look at the curriculum, look at their grade book, look at what is required to complete their portfolios, submit their homework online, get feedback and self-evaluate....It means changing the school and classroom relationship so that instead of the teacher being seen as the provider and students as the consumers, everyone is working together cooperatively. Teachers become facilitators. The hardware is simply another tool for learning.

This chapter examines various aspects of the use of technology in education. The first section (3.2) outlines current issues in teaching and learning. The Internet is relatively young but the use of technology in education is not a new practice. Over the years, the influence of technology in education has been viewed with mixed feelings. The Internet relies on computers; hence, any negativity on the use of computers in the classroom has the potential to impact on the use of the Internet in education. Section 3.3 outlines some of the technologies, which have been used in classrooms in the past century, and some of its criticisms. Section 3.4 discusses a case for the Internet in learning by outlining a variety of advantages, which support its use. Section 3.5 outlines some of the problems associated with the implementation of this technology in learning. Section 3.6 describes the reasons for choosing the WEBLEI as one of the instruments for gathering quantitative data. The last section provides a summary of the aspects covered in this chapter, which underpins this research.

3.2 THE CURRENT TEACHING AND LEARNING DEBATE

In most societies, schools are viewed as institutions that students attend to learn and become educated. However, the manner in which this process occurs has been debated and refined many times in history and the debate is still raging. Berryman (n.d) argues that the five assumptions of formal schooling were wrong:

1. People predictably transfer learning from one situation to another.
2. Learners are passive receivers of wisdom – vessels into which knowledge is poured.
3. Learning is the strengthening of bonds between stimuli and correct responses.
4. Learners are blank slates on which knowledge is inscribed.
5. Skills and knowledge, to be transferable to new situations, should be acquired independent of their contexts of use.

(p. 1- 3)

Adam and Eve did not start the present system of schooling where students converge in a central location and are taught by one teacher (Dierker, 1995). Dierker pointed out that this method of teaching was implemented, primarily to optimize the use of human and physical resources. Has our education system and teaching methods evolved over time? According to Connick and Russo (as cited in Fowler, 1995) educational systems were periodically redefined to meet the evolving needs of the society, but in teaching, changes occurred at irregular intervals and in virtual isolation. They used Papart's comparison and pointed out that teachers who taught 100 years ago could enter a classroom of today, and still teach with the equipment available to them. Chalk and talk dominated the classroom then, and in many classrooms across the globe, this is still the case. On the other hand, a surgeon from that era may have difficulties in functioning effectively in today's operating theatres. The human race has marched on with time, yet the classroom has evolved little. Despite evidence of the benefits of varied learning styles, students are still subjected to old and outdated teaching methods. In some situations, this may be the only option but in others, educators are reluctant to step out of their comfort zones and take on new challenges.

As the Twenty-First century dawned, there was a growing concern globally that the education system had not kept pace with the evolving society. In 1983, *A Nation at Risk* was published which highlighted the problems of schooling in America (Conway, 1997). There was a need for schools to produce lifelong learners. For this to occur, there was a challenge to produce "a pedagogical shift from transmitting a body of expected knowledge" that was "largely memorized" to one that was "largely process oriented" by overcoming the traditional concept of intelligence which also included "an overemphasis on verbally-loaded skills" (Conway, 1997, p. 1).

In subjects like science (discussed in detail in Chapter 4), opinions of experts reiterate the views expressed above. For instance, Lowe (*Science Initial in-service materials,* 1999, p. 24) pointed out that science education was still based on the "Moses model", where the elderly, usually male experts brought down "tablets of stone carrying eternal verities" and students were expected to memorise the contents. Because of such an approach to learning, many students viewed science as boring, irrelevant and had a "Where will I use this*?"* attitude. In the past decade, the Internet has emerged with the potential of being a significant learning tool. However, many technologies have come and gone. Despite huge promises of influencing the classroom landscape, little has changed.

3.3 USE OF TECHNOLOGY IN EDUCATION

Emerging and existing technology has always played an important part in improving the quality of education. However, what is technology? According to Dowling and Harland (2001), for the past 50 years the definition of technology has changed as the society was exposed to newer technologies. Jones (1999) pointed out that

Instructional Technology taught "the how" and Educational Technology taught "the why." Dowling and Harland (2001, p. 2) described Educational technology as the "process of analysing learning tasks and the products that come from them."

Blackboards, pencils, slates, radios, movie projectors, video players, overhead projectors, and computers have been widely used for a long time. Over the years, the invention of new technologies offered new pathways for educators to reach their learners. In 1913, Thomas Edison predicted that the motion picture would revolutionize the schooling system by replacing books within 10 years (Low, 2003; Noam, 1998). Some years later, the invention of the radio emerged as another ray of sunshine for innovative educators. In 1932, Benjamin Darrow, founder and first director of the Ohio School of the Air, was quoted as having said that:

> The Central and dominant aim of education by radio is to bring the world to the classroom, to make universally available the services of the finest teachers, the inspiration of the greatest leaders... and unfolding world events which through the radio may come as a vibrant and challenging textbook of the air.
>
> (http://cyberlearn.fau.edu/drodney/intro_to_edtech.htm)

Television followed the radio and as the technology "bandwagon" gained momentum through the classrooms, educational psychologists also felt optimistic that such innovations would deliver accelerated outcomes amongst learners. In early 1960, the psychologist Skinner (as cited in Oppenheimer, 1997) believed that with the aid of teaching machines and programmed instruction, students could learn twice as much in the same time and with the same effort as they could in a standard classroom.

The personal computer revolution that began more than two decades ago introduced yet another variable in the teaching and learning process. In 1984, Seymour Papert a pioneer in computer-based learning wrote:

> There won't be schools in the future.... I think the computer will blow up the school. That is, the school defined as something where there are classes, teachers running exams, people structured in groups by age, following a curriculum –all of that. The whole system is based on a set of structural concepts that are incompatible with the presence of the computer.... But this will happen only in communities of children who have access to computers on a sufficient scale.
>
> (http://cyberlearn.fau.edu/drodney/intro_to_edtech.htm)

In the past century, each new technology, commencing with the motion picture, offered new hope to educators especially in countries where such technologies were readily available and affordable. In less than a decade, the Internet has emerged as a significant variable in the teaching and learning process. While many have taken an optimistic view of technology, others have taken another stance.

Numerous researchers (e.g., Mitra & Steffensmeier, 2000) have questioned the pedagogical usefulness of computers in teaching. Some have shed considerable doubt on the effectiveness of computers. Roblyer (1999) referred to the delivery truck debate initiated by Richard Clark who said that computer-based instruction was merely like a vehicle that delivered instruction but did not influence student achievement any more than a truck delivering groceries causes changes in nutrition. What mattered to student learning was the way the content was being delivered rather than the method of delivery. Many view computers as learning tools that should only be used if it had the potential to generate measurable improvements in student achievement (Weaver, 2000). Michael Schrage (as cited in Dierker, 1995) of the Los Angeles Times believed that computers were irrelevant to the quality of education. He even went on to suggest that a school board would deserve to be impeached or voted out if it imported computer technology without insisting on explicit guarantees for improved student performance (Dierker, 1995). Oppenheimer (1997) echoed similar views when he criticised the Clinton Administration's push for computers in every classroom. Oppenheimer believed that such a dubious nostrum was being implemented at the cost of cutting programs in music, art, and physical education.

Some others have an even more pessimistic view of computers. Cuban (1996) argued that new technologies had a history of creating false hope in terms of how they could transform the classroom landscape. Cuban believed that:

> ...as successive rounds of new technology failed their promoters' expectations, a pattern emerged. The cycle began with big promises backed by the technology developers' research. In the classroom, however, teachers never really embraced the new tools, and no significant academic improvement occurred. This provoked consistent responses: the problem was money, spokespeople argued, or teacher resistance, or the paralysing school bureaucracy. Meanwhile, few people questioned the technology advocates' claims. As results continued to lag, the blame was finally laid on the machines. Soon schools were sold on the next generation of technology, and the lucrative cycle started all over again.
>
> (as cited in Oppenheimer, 1997, pp. 45-46)

Oppenheimer (1997) also referred to *Classrooms of Tomorrow*, a project sponsored by the manufacturers of Apple computers in early 1980. According to Oppenheimer, it was probably one of the most widely studied projects that was aimed at assessing the impact of computer technology on students. While the management hierarchy concluded that the project positively showed the benefits of using this technology, Oppenheimer (1997) argued otherwise and pointed out that the $25 million donation of computer hardware and software to thirteen schools produced limited evidence to demonstrate that computers enhanced student achievement. Schwartz (as cited in Oppenheimer, 1997) agreed that computer software had the potential to expand children's minds in maths and science but almost 99% of such computer packages were terrible. There were other problems with computer usage as well. According to Arbetter (1990), computers developed the left-brain more than the right brain. The left-brain controlled verbal and analytical activities and such dominance promoted thinking ability in individuals. The right brain on the other hand controlled visual-spatial or non-verbal activities and subsequently promoted feeling qualities in individuals. On these grounds, Arbetter's claims warrant further investigation because excessive use of computers has the potential to redesign the characteristics of the human race in future.

While some of the issues raised by the critics are warranted, the question of why technology failed in the classroom needs to be addressed. Many technologies have failed because the cost of producing learner-friendly programs has been prohibitive. The availability of suitable personnel and resources for such purposes has also been an inhibiting factor. For the production of radio and television programs for instance, there has always been a need for the intermediaries who are specialists trained in program production. Consequently, the development of programs has been out of the teacher or educator's hands.

The Internet on the other hand enables educators to reach their learners effectively and efficiently with minimal training and software requirements. It uses the computer but is more than computer-based learning. Does the Internet have a greater potential for success when other technologies have not been so successful? McInerney and McInerney (2002) pointed out that merely using a computer might not be sufficient to create a positive cognitive change. Other research has suggested that cognitive effects could be devised to direct the user's mental efforts on abstract thinking skills and strategies when engaged mentally (McInerney & McInerney, 2002; Salomon, Perkins, & Globerson, 1991). The simplicity of Internet technology creates a far greater chance to engineer cognitive changes in learners than any of the other technologies discussed in this section so far. In the next section, a case for web-based learning is presented.

3.4 A CASE FOR THE INTERNET

Rowe (2001) believed that the Internet could influence the world to the same extent as the Industrial revolution. He pointed out that digital revolutions in computers, communication, and convenience could significantly accelerate global changes this century. Rowe's suggestion of a global change when applied to a classroom situation generates new and unseen challenges.

How to define or describe learning which incorporates the Internet is a challenge in itself. Definitions and descriptions vary between individuals. For instance, e-learning has been defined as a wide set of applications and processes that use electronic media such as computer-based learning, virtual classrooms, and digital collaboration to deliver education and training (Eklund, Kay, & Lynch, 2003). Online or web-based learning is increasingly understood to be a subset of e-learning. Mayadas (2001) believed that there were two types of online learning – self-study and interactive. Allen and Seaman (2003) defined courses based on their online contents as follows: 1% to 29% online content was termed a web-facilitated course, 30% to 79% was a blended or hybrid course and an online course had greater than 80% online content. Blended learning formed the basis of the research study described in this thesis.

Numerous researchers have pointed out that there was a lack of consistent evidence to either support or oppose the advantages of using these new technologies in education (e.g., McInerney & McInerney, 2002). Such findings were expected in view of the fact that the Internet was still in its infancy and there were countless ways in which it could be implemented in education. This section outlines reasons supporting this new technology and suggests why the future for online learning and teaching appears quite positive. Eleven reasons are outlined below:

3.4.1 Many have access to the Internet

In the last 15 years, there has been a significant growth in the home and school personal computer market (Rowe, 2001). Schools in states like Victoria, Australia already have a student to computer ratio of 5:1 (Jackson, 2001) and it is estimated that up to $US 4 trillion was spent globally on the acquisition of ICT (Macfarlane, 2000). Most Australian schools have Internet connections, which are used for teaching and learning across the curriculum (Dowling, 2002). Since 2001, all state schools in Queensland have an Internet connection (Beattie, 2001). In Queensland State Schools, it is expected that ICT would be engaged in the delivery of 40% of the learning outcomes across subject and learning areas by the end of 2005 (*Information and Communication Technologies for Learning*, 2004). Teachers would also be expected to plan, deliver, assess, and report using ICT by the end of this period.

The United States appears to have led the world in terms of incorporating the Internet as part of the delivery of education programs. According to Allen and Seaman (2003), 81% of all institutions offered at least one fully online or blended course while 67% considered online education as a critical long-term strategy for their institutions. Likewise, changes have occurred in homes as well. According to the Australian Bureau of Statistics, in 2002 there were 61% of households which had a computer and 46% had Internet access (Australian Bureau of Statistics, 2003). Comparatively, in 1998, 44% households had computers and only 16% had Internet access. The Australian Bureau of Statistics (2003) also reported that the number of adults using the Internet in 1998 had grown from 31% to 58% in 2002. While there was growth in Internet use in homes, overall, the total number of Internet subscribers (household, government, and business) increased from 3.7 million in 2001 to 4.5 million in 2003 (Australian Bureau of Statistics, 2004). These figures demonstrate that the Internet was becoming more accessible in schools and homes and was no longer a tool that was available to a privileged few (McInerney & McInerney, 2002). According to Meyers (as cited in *Jobs eNewsletter 20,* 2003), while 70% of Australian households have at least one computer, many were underutilized for recreational, educational, or work purposes because many people did not fully understand how to use them.

If growth in online education continues, teaching online will become a part of many traditional research-based universities (Hislop & Atwood, 2000). Eklund, Kay, and Lynch (2003) predicted that in ten years time the ICT landscape would change substantially. They believed that laptops will have a larger market share, mobile phones will form the basis of "M-learning", and successful e-learning technologies in homes and businesses will dominate teaching and learning practices. E-learning has been embedded in policies of many organizations and there is a need for schools and other educational institutions to produce lifelong learners who can successfully transform these policies into reality in the future.

3.4.2 The Internet environment supports the findings of brain research

The brain is an important bridge between teaching and learning. The design of new teaching methods is futile unless it is compatible with the brain's ability to meaningfully extract the information and apply it either almost instantly or in the future. Brain research in the past 50 years has led to many conclusions. Caine and Caine (1991) proposed learning principles that could be used to design brain-compatible teaching methods. Many of their principles could be transformed effectively into reality through web-based teaching. Caine and Caine (1991) outlined these principles:

1. The brain was a parallel processor.
2. Learning engaged the entire physiology.
3. The search for meaning was innate.
4. The search for meaning occurred through patterning.
5. Emotions were critical to patterning.
6. The brain processed parts and wholes simultaneously.
7. Learning involved both focused attention and peripheral perception.
8. Learning always involved conscious and unconscious processes.
9. We have at least two different types of memory: a spatial memory system, and a set of systems for rote learning.
10. We understand and remember best when facts and skills are embedded in natural, spatial memory.
11. Learning was enhanced by challenge and inhibited by threat.
12. Each brain was unique.

(p. 80-87)

Other researchers have supported some of the ideas proposed by Caine and Caine (1991). For instance, Vygotsky, Bess, and Jensen (Tomlinson, 1993) believed that the brain learnt best when the context provided a moderate challenge. However, if the task was too difficult, the learner's brain shifted into a self-protection mode. On the other hand, if the task was too simple the learner's thinking and problem-solving ability diminished and he or she drifted into a relaxed mode. Jensen (1998) pointed out that attention was directly proportional to the specialized brain activity.

A website that had varied hands-on real-life (e.g., Virtual reality, *Webcams*) or interesting activities (Simulations, Virtual tours), was well-structured and offered easy to moderate challenges, could address numerous findings of brain research discussed above. In a traditional classroom, the creation of such opportunities is restricted in terms of resources and time limitations.

The success of a traditional classroom depended on learners' abilities to concentrate for prolonged periods. According to Jensen (1998, p. 46), this was counterproductive for three reasons:

a) Much of what is learnt cannot not be processed consciously because it happened too fast.
b) Internal time is needed to create meaning. The meaning is generated from within and not externally.
c) After each learning experience, learners need time for the learning to imprint.

In a traditional classroom and in subjects like science, learners are at times subjected to prolonged teacher-driven instruction. According to Jensen (1998), such an approach was counterproductive because it did not enhance learning. A learner could pay attention to either his or her teacher or make meaning from the work that was being taught. The two processes could not occur simultaneously. Consequently, learners needed time intermittently during lessons to reflect on what had been taught. Learning was dependent on synaptic connections between brain cells. According to Jensen (1998) with time, synapses and neural connections could be strengthened provided they did not have to respond simultaneously to other competing stimuli. In traditional classrooms, students are sometimes subjected to prolonged periods of teacher-driven instruction and they are expected to make meaning of the work that was being taught simultaneously. According to Jensen (1998) such competing stimuli does not enable synapses and neural connections in students' brains to strengthen effectively.

Jensen (1998) proposed that in order to enable the brain to make all necessary associations, external stimuli had to be shut down in order to give learners processing time for new learning materials to solidify. He proposed that when teaching in-depth or new content to novice learners, a processing time of between two to five minutes was needed for every 10-15 minutes of direct instruction. Jensen (1998) also suggested that the duration of direct instruction had to be proportional to a learner's age. The use of the Internet enables learners to progress at their own pace. It also enables them to review and revisit their work when necessary. The flexibility enabled learning to occur at anytime, and was ideal for students on and off-campus. Bishop and Henderson (2001) found that such an approach was a useful add-on to one on one instruction for students who needed additional support or needed to review their work following a conventional lecture.

3.4.3 The Internet blends in with popular theories of educational psychology

According to Saloman (1998), technology was growing at such a pace, that for first time it was outpacing pedagogical and psychological theory. Wang and Bonk (2001) also pointed out that human cognition and the social context of thinking were essential prerequisites in the success of technology-based learning environments. Hence, any use of ICT had to connect successfully with theories of educational psychology.

In the past 100 years, teaching and learning practices in classrooms have been guided by the ideas and theories of numerous educational psychologists. Prior to 1970, good education in the classroom was dominated by the theories of Behavioural Psychology whereas the present day focus is more on the theories associated with Cognitive Psychology which appear to be a better approach to preparing students to become lifelong learners (Conway, 1997).

Behavioural psychologists, Watson and Skinner proposed their theories of Classical conditioning and Operant conditioning respectively (Schell & Hall, 1979). Their theories suggested that human behaviour was primarily a result of experience. They believed that teachers could link together responses involving lower-level skills and create a learning chain to teach higher-level skills (Conway, 1997, p. 1).

Jean Piaget and Lev Vygotsky believed that learning was an intended process of constructing meaning through experience (McInerney & McInerney, 2002). However, Piaget and Vygotsky explained the manner in which this meaning was constructed differently. Piaget believed that a child's intellectual ability was linked to his or her developmental maturity. He believed in the importance of unstructured experiences and self-initiated discovery for children's cognitive development (McInerney & McInerney, 2002). McInerney and McInerney (2002) also pointed out that Piaget believed that higher mental processes were typified by structured activities and cognitive development occurred independently of language development.

Vygotsky proposed that all learning took place in the zone of proximal development (McInerney & McInerney, 2002). This zone was the difference between what a learner could do alone and what he or she could do with assistance from other individuals (Vygotsky, 1978). By building on the child's experiences and providing moderately challenging tasks, teachers were in a position to provide intellectual scaffolding to help children learn and progress through the different stages of development (Conway, 1997, p. 1). Research by Salomon, Globerson, and Guterman (1989) and Salomon, Perkins, and Globerson (1991) on computer-designed reading activities led to improved outcomes in not only reading but also essay writing skills. They pointed out that the computer in this instance acted as a "more capable peer" by enabling "mindful learners to engage in cognitive processes of a higher order than the ones they would display without this partnership" (Salomon, Perkins, & Globerson, 1991, p. 5). However, for learners to achieve the desired outcomes, the technology must provide unambiguous human-like support. McInerney and McInerney (2002) pointed out that while the theories of Piaget and Vygotsky varied, they both believed in the active involvement by children in learning.

Piaget and Vygotsky (McInerney & McInerney, 2002) believed in the process rather than the product of learning. The importance of peer interactions during the process was important. They emphasized the need for designing learning experiences that were relevant to real world scenarios and catered for individual differences between learners. Numerous technical options on the Internet offered flexibility, which created opportunities for "real world" experiences and addressed the needs of individual learners. For instance, the use of virtual reality and live *Web cams* creates two unique opportunities for learners. Firstly, it enabled learners to interact actively with their learning environments and secondly it allowed theoretical concepts to be connected with concrete ones (McInerney & McInerney, 2002). It supported Piaget's idea of "experience with the world" for a learner's intellectual growth and it supported Vygotsky's emphasis of "active involvement in learning and the value of auxiliary stimuli" (McInerney & McInerney, 2002, p. 168).

School curricula have also been influenced by other views of intelligence and cognition. Howard Gardner's theory of multiple intelligences proposed nine intelligences that were shaped by time, place, and culture in which the individuals developed (McInerney & McInerney, 2002). These intelligences are linguistic, logical-mathematical, musical, artistic, spatial, bodily kinaesthetic, interpersonal, intrapersonal, naturalist, and existentialist. Gardner also believed that each of the intelligences evolved independently of the others (McInerney & McInerney, 2002).

In most modern societies, intelligence appears to be directly proportional to performance in schools and especially in subjects like mathematics and the languages (McInerney & McInerney, 2002). Gardner's theory has challenged the traditionally held views of intelligence. While in some school subjects learners have an opportunity to express their competence in tasks that draw on various intelligences, in high school science, such opportunities were rare. Conway (1997) pointed out that by giving students a chance to demonstrate their abilities through a wide variety of intelligences, it boosted their confidence and enabled them to undertake learning tasks with increased confidence.

Three of Gardner's ideas (McInerney & McInerney, 2002) can be addressed by a suitably designed website. Firstly, he emphasized the importance of mentoring practices in a social framework in which a learner's intelligence develops. A suitable developed website can perform the task of a more capable peer by providing human-like guidance (as discussed above). This result can also be achieved through suitable online discussions (chat rooms), *Facemail* (www.facemail.com) and networked video conferences (e.g., http://gsh.lightspan.com). Secondly, such a development should occur in an authentic environment. The use of virtual reality and *web cams* create authentic environments. Thirdly, learning should have an interdisciplinary approach. A well-designed website with suitable hyperlinks promotes nonlinear thinking (McInerney & McInerney, 2002). It not only links the pages or concepts within the site, it can also be linked to other suitable sites globally which do not have to be related to the same discipline. The use of a suitable search engine opens a world, which goes well beyond the confines of any traditional classroom or textbook.

3.4.4 The Internet supports different teaching and learning styles

Students' learning styles, their motivation, and their prior experience often dictated their ability to learn (Roblyer, 1999). In a traditional classroom, catering for a variety of learning styles can be a challenge. Web-based learning on the other hand has a greater flexibility. According to McInerney and McInerney (2002), intellectual partnerships with computers distribute the resources between persons, situations, and tools. Conway (1997) outlined four ways (described below) in which educational technology supported specific techniques of teaching and learning.

i) Direct Instruction/Explicit Teaching

In this approach, students are presented with materials in small steps followed by checking for their understanding. The approach enabled active and successful participation of all students (Rosenshine, 1986). This model of instruction was classified as a 'transmission model' (as opposed to 'information-processing model') which was well grounded in the behaviourist theory. According to Rosenshine (1986), the following six steps formed the basis of the explicit teaching approach - daily review, presenting new material, guided practice, corrections and feedback, independent practice, and weekly and monthly reviews. While such an approach worked with teaching facts, concepts, vocabulary, and map skills, it was found to be less relevant for teaching in areas that were less well-structured (Rosenshine, 1986). These included areas such as teaching composition, reading comprehension, analysing literature and historical trends.

ii) Cooperative/Collaborative Learning

In this cognitive approach to learning, academic materials are mastered through collaborative group work. The teams consist of learners of varying abilities, gender, and cultural backgrounds. Reward systems are group-oriented rather than individually oriented (Conway, 1997). This approach has many variations. Two of the ways described by Arends (1994) included the *Student Teams Achievement Divisions* (STAD) in which students were either given worksheets or assigned other educational tasks. They worked as a group and helped each other to learn. All students individually took a weekly quiz that gave them an improvement score. This score measured the extent to which it exceeded student's past average and all teams strived to get a good team improvement score. The Jigsaw approach was the other method. In this case, each member of the team was expected to become an expert in one aspect of the academic task which was assigned to the group. It was then his or her responsibility to teach the others in this group the appropriate aspect of the task. Members from other teams who were experts on the same topic also shared their acquired skills and knowledge to help each other and this information was then relayed back to their own group members. At the conclusion of the exercise, each group presented its findings to the class.

iii) Discovery Learning

Jerome Bruner was very closely associated with the discovery learning approach. The philosophy of this method of teaching is embedded in cognitive psychology and this approach hinged on the belief that students were more likely to remember concepts which they discovered on their own (Conway, 1997). According to Roblyer, Havriluk, Edwards, and Havriluk (1997) teachers found discovery learning to be more successful when students had the prerequisite knowledge and underwent some structured experiences.

Modern technology such as *vrml markup* language utilizes the Internet and enables students to take virtual tours, virtual field trips and explore new surroundings, make new discoveries, and draw conclusions. Participation intensified the learning experience (Dierker, 1995). The Internet created new learning opportunities by enabling individual learning experiences. It also enabled students to venture beyond the walls of their classrooms and had the potential of enabling students to interact with others across the globe (Dowling & Harland, 2001).

iv) Cognitive Apprenticeship

Cognitive apprenticeship is a method of teaching which aims to show learners the steps followed by experts to handle complex tasks. Wang and Bonk (2001) proposed a framework for electronic cognitive apprenticeship, which included modelling, coaching, scaffolding, articulation, reflection, exploration, questioning, task structuring, performance feedback or management, and direct instruction (Bonk & Kim, 1998; Collins, Brown, & Newman, 1989). This approach to learning was initially proposed by Collins, Brown, and Newman (1989, p. 487) who pointed out that:

> The reason that Dewey, Papert, and others have advocated learning from projects rather than from isolated problems is, in part, so that students can face the task of formulating their own problems, guided on the one hand by the general goals they set, and on the other hand the 'interesting" phenomena and difficulties they discover through their interaction with the environment.

The website *Getsmart* was designed specifically for this study. While it addresses numerous teaching styles mentioned so far, the design of *Getsmart* was predominantly underpinned by the instructional methods of cognitive apprenticeship. The design of *Getsmart* and cognitive apprenticeship is discussed further in Chapter Six.

3.4.5 The Internet engages learners as active participants

Taylor (as cited in Saddik, 2001) pointed out that the most valuable aspect of using computers in education was that students were engaged as participants in the process of learning rather than as spectators. This view was also echoed by Billing (as cited in Fowler, 1995) who suggested that self-paced learning led to a student-centred system because students were actively interacting with a vast amount of information. Arsham (2002, p. 4) described the value of the Internet in this regard as follows:

> A Web-based class is a more effective learning experience, since the learner is participating in learning process and receives individual attention...The Web-based learning atmosphere allows more effective interaction between students and instructor....it can be as effective as traditional classroom.

Campos, Laferrière, and Harasim (2001) studied the teaching practices in more than one hundred mixed courses in the USA and Canada which used asynchronous electronic conferencing in post-secondary settings. Their findings suggested that the educators were re-discovering new technologies that were reinvigorating their enthusiasm for teaching. Networked classrooms were creating opportunities for collaborative knowledge construction and building (Campos, Laferrière, & Harasim, 2001). Campos, Laferrière, and Harasim described these networked classrooms as socio-cognitive mixed-mode learning spaces where the teacher and the learner had central roles in pedagogical actions. It was also an environment where the educator intervened to promote collaborative knowledge sharing (Campos, Laferrière, & Harasim, 2001).

Asynchronous learning networks (ALN) did not give learners spontaneous access to a facilitator but it did work well for those students who were shy and did not ask questions in class. It gave them an opportunity to think through their questions and forward it by the calmer medium of electronic mail (Gomory, 2001). In an asynchronous interaction using web-based conferencing, Järvela and Häkkinen (2000) found that there were different levels of interaction. Higher levels of perspective talking led to higher levels of discussion. In ALN environments, courses with a laboratory component could be a problem but instant feedback to homework and an accessible user-friendly website greatly sustained student interest (Gomory, 2001).

3.4.6 The Internet enables teachers to cater for a variety of student needs

> The biggest mistake of past centuries in teaching has been to treat all children as if they were variants of the same individual, and thus to feel justified in teaching them the same subjects in the same ways.
>
> (Gardner as cited Siegel & Shaughnessy, 1994, p. 564)

Sarason (1993) believed that there was an overwhelming desire amongst learners to engage in learning with different teaching methods. According to Sarason, the present "one-size fits all" delivery system where everyone supposedly learnt the same thing at the same time, irrespective of the learner's needs, did not always optimize learning outcomes.

One of the ways in which the Internet could address this issue was by creating a differentiated classroom. According to Tomlinson (1993), in such classrooms, teachers responded to learners needs by varying their teaching methods. Some of these methods were highlighted in section 3.4.4. By applying a variety of management and instructional strategies, teachers could appropriately modify the content, process, or product according to the learners' interests, readiness, and learning profiles.

In a differentiated classroom, assessment was "today's means of understanding how to modify tomorrow's instruction." (Tomlinson, 1993, p. 10). Assessments were an ongoing process which did not appear at the end of a unit of work. Such assessments could be conducted by a variety of methods that in turn provided valuable data for creating a learning environment conducive to learners' needs. A website with varied options suitable for learners with various abilities (as discussed above) addresses the issue of special needs and has the potential to improve academic outcomes (McInerney & McInerney, 2002). The inclusion of online tests in websites also provided learners with valuable continuous feedback.

3.4.7 The Internet motivates students to learn

According to Jensen (1998), there were two groups of factors which influenced attention for learning. Learning which was relevant, offered choices and was engaging increased intrinsic motivation. As discussed earlier, such learning had the potential to capture learners' attention for 10 to 90 minutes. On the other hand, learning which lacked choices, was irrelevant and passive increased boredom and dislike. Such learning engaged learners' attention for 10 minutes or less. Is this one of the reasons why children "switch off" periodically in traditional classrooms?

Jensen (1998) also pointed out that the academic success of students depended on the ability of students to tune in like a radio to an exact, focused bandwidth. According to Jensen, priming also influenced learners' abilities to pay attention. Priming guided learners and prompted them to look for things in specific locations. Self–paced systems not only diagnosed learner's capabilities, but it was also customized and monitored the delivery that many learners found motivating (McInerney & McInerney, 2002).

A carefully designed website with suitable pedagogy has the ability to promote intrinsic motivation and enables students to tune in. It can also constantly prime students (through hypertext, eye-catching graphics, and animation) to focus on the necessary information. In a traditional classroom, this may not always be feasible. Numerous studies have demonstrated positive influences of web-based learning on students. For instance, Chan, Hodgkiss, and Chan (2002) developed a website to teach students freshwater ecology. While no comparison was made between web-based and traditional practicals, they reported that students enjoyed such an approach and they found that their interest in ecology was enhanced.

3.4.8 The Internet removes time constraints of learning

Until recently, learning in traditional schools has been dictated by school hours and lesson times. The Internet has overcome this barrier by enabling motivated learners to access websites at times and locations convenient to them.

The Internet had redefined the opening and closing hours of teaching and learning. Referring to the Internet, Newt Gingrich, a former Speaker in the USA House said that by making education available twenty-four hours a day, seven days a week, learners could literally have a different attitude towards learning (as cited in Oppenheimer, 1997).

3.4.9 The quality of learning outcomes was encouraging

In a survey by Allen and Seaman (2003), 57% of the academic leaders believed that online education learning was capable of producing learning outcomes which were either equal to or better than the results obtained through face-to-face instruction. The Internet could be used to support a variety of teaching and learning styles. In higher education, there was optimism about this new technology because there was a growing body of evidence, which suggested that the online model of teaching worked and produced desirable outcomes (Gomory, 2001; Mayadas, 2001). According to Mayadas, learning via the Internet encompassed a balance between three key elements: learning materials, access to a facilitator, and interaction between the learners. These three elements were also essential for the success of students in traditional schooling. "While an ALN is an attempt to reproduce the basic elements of classroom teaching, it is certainly not the same as classroom teaching" (Gomory, 2001, p. 141). In such environments, the Internet acted as a medium for distributing learning materials (Mayadas, 2001).

Dutton, Dutton, and Perry (2002) found that while lecture and online students had different characteristics, their performance in courses was also different. Online students obtained higher grades but the researchers pointed out that the effect was not statistically significant. Homework completion had a positive correlation with both modes of delivery. They also found that prior computer experience improved grade performance and age had almost no influence. The researchers pointed out that since their research was conducted in a computer course, students undertaking online learning were probably more computer literate than were students in other disciplines. Consequently, the findings of the study reported by Dutton, Dutton, and Perry (2002) may not be replicable in other disciplines.

Holland (2000) also reported that learning effectiveness was the same in both types of courses and students learned well when they understood the work and sufficient resources were provided. Picciano (2002) studied the impact of student interaction on performance. Over a period of 14 weeks, students participated in online discussions through the *Blackboard* course management system. The number of times messages were posted was recorded. For analytical purposes, the respondents were divided into three interactional groups – low, medium, and high. While the level of interaction did not influence exam results, there was a positive relationship between the level of interaction and the written assignment assessment task. Picciano (2002) pointed out that the assignment assessment was similar to situations presented on the weekly discussion board. Loomis (2000) used the *Learning and Study Strategies Inventory* (LASSI) to study the relationship between learning styles and performance. Loomis found that while there was a correlation between five scales of LASSI and one aspect of course assessment, the correlation was highest between time management skills and the final grade.

While students had a positive attitude about their online course, Spiceland and Hawkins (2002) found the students enrolled in this mode held a less than favourable response in their ability to learn when compared to traditional classroom settings. They also suggested that an active learning format could enhance learning. Parker and Gemino (2001) studied the difference between the learning outcomes of students enrolled in a third year Business Administration course in a traditional "place based" and in an online "virtual seminar" mode. The course had two objectives. Firstly, students' had to understand the nature and the importance of the role of a system analyst. The materials associated with this objective were abstract and conceptual in nature. The second objective dealt with the use of technical tools. The researchers found that students who enrolled in the virtual seminar mode scored significantly higher in the conceptual section of the final exam than those in the place-based mode. The results were reversed in the technical section. Parker and Gemino (2001) suggested that the best of both worlds should be incorporated in teaching and their suggestion leaned more towards a blended approach.

Wegner, Holloway, and Garton (1999) reported that there was no difference in the academic outcomes of those who were enrolled in an online mode from those enrolled in the traditional mode. While the statistical analysis of the data gathered on students' perceptions was not statistically significant, general observations suggested that students in the online group had a more positive feeling about their experience. They pointed out that the novelty effect of the new medium could have influenced students' experiences. In a research focused on the dimensions of successful online learners, Schrum and Hong (2002) identified seven dimensions. These were: access to tools, technology experience, learning preferences, study habits and skills, goals or purposes, lifestyle factors, and personal traits and characteristics. They also proposed online teaching strategies such as frequent interaction, collaboration, questions-asking *Forum*s, and minimizing technology requirements as important variables in the success of these learners.

Students became upset and anxious if they encountered technical problems and this led to a lost learning opportunity (Holland, 2000). Students also expected frequent involvement of the instructor who responded accurately to their concerns in a timely manner. While designing collaborative learning activities was a challenge, Holland (2000) found that many students did not know how to collaborate even though they were at university level and discussions tended to become a conflict between quality and quantity. Lack of good real-time interaction support tools also restricted communication. The researchers used *Blackboard Classroom* as an interface for interactions and found that most comments were restricted to concerns about the medium. Students did not post any comments that were not relevant to the course (Curtis & Lawson, 2001).

The Sloan consortium has provided more than 4,000 faculty-semesters of ALN teaching experiences and the organization had in excess of 100,000 enrolments in 2001. According to Gomory (2001), students not only took courses, they were actually learning and, without exception, off campus and on campus groups usually scored the same. While Gomory's conclusions were based on his observations with a large number of students enrolled in an off-campus mode of learning, the findings could vary significantly because there are many variables which could influence the outcomes of an Internet-based learning environment.

3.4.10 Internet based learning has produced positive outcomes in science subjects

Talsma (2000) researched on the value of computer models in a high school science creek project. Talsma found that there were significant gains in students' scientific understanding of their project that was not because of the computer models alone. The gains were attributed to the quality of the learning environment, which promoted enquiry and involved collaborating, reviewing, and revising during artefact construction.

The introduction of an online format in an advanced university chemistry course encouraged more students to enroll in the subject because they liked the flexibility of the course (Shapley, 2000). Shapley pointed out that course flexibility catered for students with special needs and increased interaction enabled all students to progress at their own rates, and improved student performance on exams that required complex reasoning skills. Dori and Barak (2000) used virtual and physical models in high school chemistry to improve students understanding of organic molecules. They found enhanced learning outcomes for these students. The researchers found that these students had a significantly better understanding of the work and their ability to apply the knowledge was better than those who had not used these models.

Kashy, Thoennessen, Albertelli II, and Tsai (2001) found that the implementation of ALN in an introductory physics course at Michigan State University influenced positively on students' success rates. The rationale of such an approach was to modify and complement the existing course. The study also showed that most staff held the perception that they could influence outcomes because of this application. They also felt that ALN improved their relationship with students because teachers were viewed as mentors rather than judges and it increased their interaction with other departments.

3.4.11 The Internet is widely accepted by business

The incorporation of technologies as education applications often occurred after the technology had matured and been in the marketplace for a while (Eklund, Kay, & Lynch, 2003). The implementation of new technologies in education is not only difficult and expensive but it also has to be widely accepted by the users. Eklund, Kay, and Lynch (2003) pointed out that a technology was considered mature if it was stable, provided a *Return On Investment* (ROI) and fitted in with teaching and learning practices. According to Eklund, Kay, and Lynch (2003) there is a growing body of literature which suggested that e-learning was improving business performance.

Consequently, it is becoming increasingly evident that the business world has widely embraced the Internet revolution. If educational systems are determined to produce graduates who can successfully adapt to the real world, then it is important to understand and closely monitor the views of the "movers and shakers" outside education circles. Distinguished Australian businessperson, James Packer, expressed his thoughts about the Internet as follows (as cited in Linnell, 2003, p. 33):

> We believed that as a company that the Internet was going to represent a serious change to the communications landscape…it is more pervasive today than it ever has been…the Internet is cheaper, it's richer…it can be interactive. It's just a smarter medium.

According to John Chambers (as cited in Rosenberg, 2001, p. xiv), the Chief Executive Officer of Cisco Systems, "The biggest growth in the Internet, and the area that will prove to be the biggest agents of change, will be in e-learning". Businesses such as IBM for instance, had already embraced this new revolution. It was widely believed in these circles that global economies were no longer dependent on mass production of goods as was the case during the industrial era. According to Ranieri (2000), the success of businesses depended on how corporations addressed the needs of individual customers. Will the success of education systems also depend on such a philosophy in future? Experienced educators highlighted the convenience factor, which made this mode of learning very attractive:

> For the first time lifelong learning can be more than just a phrase but rather a real possibility for large numbers of people who want to learn but can not leave their jobs to do so...from an individual's point of view it will never be too late to learn.
>
> (Gomory, 2001, p. 144-145)

3.4 PROBLEMS ASSOCIATED WITH THE IMPLEMENTATION OF WEB-BASED LEARNING

In recent times, the Internet has become more accessible and affordable. However, despite this, accessibility and affordability will always be an issue for some learners. Numerous researchers (e.g., Charp, 2001) have defined this as the digital divide. There are other problems as well. There is conflicting evidence on the relationship between gender and competence with computers. While some researchers have suggested that females were at a disadvantage because of their attitudes towards computers (e.g., Camp, 1997), others have reported otherwise (e.g., Bunt & D'Souza, 2000). Some others have reported no gender difference at all (e.g., Hartwell, Gunter, Montgomery, Shelton, & West, 2001). Wang and Bonk (2001) reported that while males obtained better grades in an online economics course, the means of the two groups were not statistically significant.

A more significant problem was that teaching online courses is considered to be an extremely complex and challenging activity (Anderson, Rourke, Garrison, & Archer, 2001). There was some evidence that the role of a teacher is far more important than the instructional design of the content (Eklund, Kay, & Lynch, 2003). Gold (2001, p. 35) pointed out that "the transition from in-class room instruction to online instruction is a complex one involving specialized training in the technical aspects of delivering quality educational materials (or environments) to the students, and specialized training in how to foster knowledge acquisition within this new environment". Mayadas (2001) suggested that the outcomes of such initiatives depended largely on teaching ability, motivation, and experience of the teachers. The demands of young learners were not met in schools largely because of a lack of teachers who were familiar with computer technology (Eklund, Kay, & Lynch, 2003).

A research study at the University of Central Florida produced two conflicting findings. While enrolment in online courses rose exponentially from 1996 to 1999, the teachers felt that such an approach did not fit into the "academy culture" (Hartman, Dziuban, & Moskal, 2000). The learners also found the approach to be more flexible and interactive. However, despite these constructive attributes of online learning, the teaching approach did not seem to influence the expectations of the "academy culture". This leads to the question - Who are the teachers teaching? Perceptions of the educators are unlikely to change overnight. Hence, as the current generation of educators retires, the incoming generation of educators may be more accustomed to accepting technology because their generation grew up with computers and multimedia (McInerney & McInerney, 2002).

Other researchers have also found that teachers played a significant role in the implementation of strategies associated with online learning. Eklund, Kay, and Lynch (2003, p. 14) pointed out that "the competence of the practitioner to access and select quality content and then integrate it into the teaching context" was an essential element in the success of the online teaching approach. Studies overseas and in Australia (Newhouse, 2000) have suggested that teacher's characteristics determined the extent to which computer supported technologies were integrated into classrooms. Many teachers lacked the expertise to create such environments. Consequently, they always looked for examples of ways in which computers could be used in their curriculum area. According to Newhouse (2001), teachers did not perceive computers to be necessary or even critically useful. Eklund, Kay, and Lynch (2003, p. 22) suggested that some teachers were unwilling to embrace online learning even if they were provided with "clear advantages of it in terms of market reach".

In a survey by Allen and Seaman (2003), only 60% of academic leaders of institutions appeared to have embraced online education as a delivery method. Lack of suitable teacher training was one possible reason which explained this tendency (Eklund, Kay, & Lynch, 2003). Ongoing teacher in-service also did not satisfactorily enhance teacher confidence nor their experience in using computer based technologies to support learning. Teacher's views on new approaches to teaching and learning and their level of motivation could also influence their teaching practices. With an expected growth of 20% in e-learning (The Sloan Consortium, 2004) attitudes towards such an approach to teaching has to change. Teachers will have to learn to like this approach to teaching and learning.

Teachers implementing technology based innovative practices were often the only ones in their schools who utilized this approach (McDonald & Songer, 2000). The success of incorporating ICT in education also depended on the support from the management hierarchy. Such support enhanced the "visibility of the project within the organization" and additional support such as "careful deployment strategy that includes training" added to the success of the project (Eklund, Kay, & Lynch, 2003, p. 14). Such recognition also encouraged other teachers within the institution to attempt innovative practices. The Internet has various websites, which are aimed at supporting teachers. For instance, SupportNet Online (http://supportnet.merit.edu) consists of a set of web-based training modules and resources that was developed to assist teachers. However, how many teachers actually access such websites?

Another significant concern is the design of an Internet enabled interactive model. Numerous ideas have been suggested to address this concern. Chen and Decary (2000) for instance, developed a *Virtual Homework Centre* (VHC) to promote collaborative problem solving in the home environment. Such a system eliminated the need for teachers to set the sequence of the learning activities. The activities were wholly student- centred where students dictated their own learning tasks.

Many researchers believed that the current web-based educational tutorials were poor in educational content (Janicki & Liegle, 2001). Internet technology is relatively new and computer programmers and those with skills in Internet-friendly languages initially designed many websites (Murray, 1996). These web developers did not have a background in teaching; hence, aesthetics and graphics of the website overtook the educational value of the product.

Janicki and Liegle (2001) incorporated design suggestions from various researchers specialising in instructional technology and web design when they produced *Web-Based Tutorial Authoring System* (WebTAS). This website was designed for adults with the following features – learning goals, pre-requisite knowledge, content in various styles, multiple examples and exercises, test questions, consistent design, presentation styles, help menus, manage feedback, and track progress (Janicki & Liegle, 2001). WebTAS had a positive response from instructors and developers but it was not trialled with learners.

The Internet had a wealth of information but some of the materials were useless. Kessell (2001) described it as a goldmine without a map. According to Schocken (2001), the vast array of tests could not be easily located using the available search criteria because the questions came in a hodgepodge of styles and formats and the publicly available questions were of a poor quality. Schocken (2001) argued that for ALN environments to gain popularity there was a need for a framework, which was distributed, component-based, non-proprietary, and standardized. Schocken also believed that the design of such a framework should include varied activities, tests, manage learner profiles, and enable both synchronous and asynchronous communication. Hiltz, Coppola, Rotter, and Turoff (2000) reported that when students were actively involved in collaborative learning online, the outcomes were as good as, if not better than those achieved by students in traditional classes. They also proposed a causal model for virtual classroom study in which favourable outcomes were dependent on factors such as technological infrastructure, organisational support, student ability and motivation, pedagogical approach, skill, and the level of effort of the teacher.

3.5 WEBLEI IN THIS STUDY

The previous section highlighted a series of questions, which needs further exploration. Firstly, the impact of a web-based learning environment on learners and how these perceptions are influenced by gender needs further research. Secondly, there is a need for more research to convince teachers that web-based teaching and learning is a realistic possibility in classrooms. Greater research evidence enhances the possibility of acceptance of such an approach by the teaching fraternity. Thirdly, there is a need for more web-based teaching models, which are backed by research and have demonstrated learner approval.

In this study, the WEBLEI (Chang & Fisher, 1998, 2003) was used to gather data quantitatively on students' perceptions of their web-based learning environment. This instrument was chosen because it could effectively address all three issues raised above. The WEBLEI measures students' perceptions across four scales – Access, Interaction, Response, and Results. All these four elements are essential for student success in such teaching mediums. The WEBLEI is also unique in the way the scales are interrelated.

According to Chang and Fisher (1998, 2003), for students to use this medium, they to have to establish contact with the Internet. Consequently, the Access scale establishes the extent to which variables associated with accessing this medium meet students' expectations. Once the students have logged in successfully, they should be able to interact productively with their peers and their teachers. Hence, the Interaction scale explores the extent to which this is achieved from the students' point of view. The Response scale gives an indication of how they felt about using a web-based medium and the Results scale gives an idea of whether they accomplished any of the learning objectives by using such a medium (Chang & Fisher, 1998, 2003).

An innovation is generally useless unless it fulfills the purposes for which it was designed. Therefore, in this study, *Getsmart* was designed for students in a blended learning environment. Many aspects of what can be achieved by web-learning (as presented in this chapter) are encapsulated in this website. The findings obtained from the WEBLEI would be very much like a report card on how this innovation performed when it was put through the real test with students. Apart from the WEBLEI, none of the existing learning instruments would successfully demonstrate the real impact of a web-based learning environment on students' perceptions.

3.6 CHAPTER SUMMARY

> New technologies usually succeed first in a niche market where they have special advantages...but having a niche to build on allows the technology to survive and grow and become more effective. In its improved form it may well penetrate a far larger market.
>
> (Gomory, 2001, p. 142)

In this chapter, evidence has been presented that the Internet has succeeded in businesses and higher institutions. High school teachers can benefit from the pioneering initiatives of these organizations. In a blended learning environment, they can extend teaching and learning beyond the four walls of traditional classrooms. Section 3.4, outlined 11 reasons which demonstrated a case for the Internet in teaching and learning.

There are a few issues highlighted in this chapter which this research addresses. Firstly, in several studies (e.g., Eklund, Kay, & Lynch, 2003), the lack of teacher in-service has been blamed as one of reasons why the Internet is not widely used in teaching. The researcher in this study is a science teacher with no in-service or formal training in ICT who designed a website for student use. This study aimed to demonstrate that teacher motivation, innovativeness, and aptitude are probably equally if not more important than teacher in-service when using new technologies. With little knowledge of technology, teachers can use the Internet creatively with their students.

Secondly, there is considerable debate on the design and implementation of web-based lessons via the Internet. In this study, a cognitive apprenticeship-teaching model primarily underpinned the design of *Getsmart*. It also fulfilled numerous aspects of cognitive psychology theories.

Thirdly, the study was conducted in a full-time high school setting where a blended learning approach was a realistic possibility. There are other reasons which support this approach. Industry-based case studies for instance suggest that amongst other factors, blended learning fulfills the needs of learners. Such an approach promotes appropriate and sometimes multiple-learning styles in one subject (Valiathan, 2002) by using the best of traditional and technology-enhanced delivery (Zenger & Uehlein, 2001). While certain aspects of online environments match with face-to-face situations, there are also significant differences (Curtis & Lawson, 2001). Online environments appeared to lack the challenge and explain cycles of interaction, which are characteristics of face-to-face tutorials (Curtis & Lawson, 2001). This leans towards a blended teaching approach where the role of teachers as facilitators is recognised as the key component for success (Eklund, Kay, & Lynch, 2003). The blended approach also enables the teacher to capture the best of both worlds in his or her teaching practices. The next chapter presents a literature review of some of the issues in science education.

CHAPTER 4

SOME ISSUES IN HIGH SCHOOL SCIENCE

4.1 INTRODUCTION

The Australian schooling landscape has changed tremendously in the past century. There are more students, more subjects options and a variety of schooling types. For instance, there are more students in Australia who complete year 12 education now then ever before. These transformations have produced new challengers to educators, parents, and education authorities. Politicians locally and internationally share similar views on issues such as the ability to use the Internet, senior schooling, and lifelong learning (Cole & Jones, 2004). At a deeper level, many of these challengers are not unique to Australia.

In secondary schooling, some significant concerns include higher rates of early school leaving for boys than girls. In 1999, 66.4% boys and 78.5% girls remained at school in their post-compulsory years (Cortis & Newmarch, 2000). This trend has been observed consistently for the past twenty years. More recently, a Queensland Government report pointed out that girls were more likely to complete high school than boys (Wenham & Odgers, 2004). Cortis and Newmarch (2000) also pointed out that the boys' selection of a narrow range of traditional subjects, their lower year 12 results together with their declining enrollment in higher education has led to a belief that some boys were failing to achieve the results of which they were capable. Traditionally, more boys enrolled in the physical sciences, which appeared to reflect their traditional view of work (Cortis & Newmarch, 2000). However, if there are fewer boys who remained at school after the compulsory years, then obviously enrolments in these subjects will drop.

As a result of the issues and concerns, governments globally have implemented new initiatives. Not all these initiatives have produced the desirable outcomes. For example, the issue of class sizes and its impact on learning outcomes has been on many reform agendas. Hurd (as cited in Gibbs & Fox, 1999) pointed out that despite the expenditure of $16.1 billion dollars by the Californian and American Federal

Governments to reduce class sizes, there was little change in learning outcomes. Perhaps other more significant variables impinge on learning outcomes. Mirza (1995) for instance, believed that the performance of pupils correlated closely with teacher expectations.

The public perception of science as a whole has been questioned and put under the spotlight. Research carried out by Reiss (as cited in O'Leary, 2001, p. c08) in the U.K. showed that science was considered to be important, "but most parents had negative memories of science at school and many teenagers had lost interest in the subject". In Australian schools, many science students lost interest in science very early in high school and this was reflected in their attitudes during science lessons (Roberts, 2002, p. c13). The next section focuses on several important issues that have hounded science educators for more than a few decades.

4.2 CURRENT ISSUES IN SCIENCE EDUCATION

The direction that science education took was sometimes the result of poorly thought- out goals. Issues appeared to be have formed a perpetual cycle over the years. According to Cizek (as cited in Gibbs & Fox, 1999), issues concerning science education have formed a cyclical ritual which appeared to have repeated itself every decade since the 1940's. For instance, the space race between America and Russia in the initial years appeared to shake the Americans whenever the Russians seemed to have the upper hand. Any evidence of the American's being second best in this race turned the spotlight on potential causes such as the quality of science education in schools. Rickoveris' book; *American Education, A National Failure* in 1963 was a good example of the national response to this concern (Gibbs & Fox, 1999).

The general perception of the community was that schools were producing fewer students who were interested in science and related areas when they left school. Gibbs and Fox (1999) also suggested that the task of producing scientists and engineers was that of universities and not schools. They also pointed out that of the 305,000 students who enrolled in college preparatory physics courses in 1988, less than 1.6% graduated with a Bachelor's degree and only 700 went onto do a doctorate in physics.

As pointed out in previous chapters, Lowe (*Science Initial in-service materials*, 1999) believed that the approach to science education was old and outdated. It is probably for this reason that many students are drifting away from the subject. The issue of the disappointing picture of science in schools (Goodrum, Hackling, & Rennie, 2001) and the diminishing numbers in science subjects is discussed below. The discussion also includes references to studies done overseas which have attempted to identify and address similar issues.

4.2.1 The "disappointing" picture of science education in schools

Goodrum, Hackling, and Rennie (2001) produced a comprehensive report titled *The Status and Quality of Teaching and Learning of Science in Australian Schools* on issues that related to science education in Australia. It was one of the most comprehensive studies conducted recently in which qualitative and quantitative data was gathered from 4,023 students (1,221 from primary and the rest from various levels of secondary schooling), teachers, and interested groups. Some of the issues raised by Goodrum, Hackling, and Rennie (2001) are discussed below:

a) The present science curriculum is not relevant to the needs, concerns, and personal experiences of many students (Goodrum, Hackling, & Rennie, 2001).

On average, the actual picture of science was disappointing and the quality of teaching ranged from brilliant to appalling (Goodrum, Hackling, & Rennie). The present system in Australia, USA, and UK appeared to address the needs of a minority who may eventually pursue a science-related career, while the needs of the majority of the students were not met (Gibbs & Fox, 1999; Goodrum, Hackling, & Rennie, 2001; Millar & Osborne, 1998).

Hurd (as cited in Gibbs & Fox, 1999) of Standard University (U.K.), pointed out that while nearly 1,000 laws have been passed since the 1970 to address this issue, there had been little change in what students learnt because many of these reforms were based on shaky evidence. Gibbs and Fox (1999) argued that, there was no reason to believe that there was a sudden decline in science knowledge of high school students. They pointed out that research showed that students today knew more science than their parents did or grandparents did. According to Gibbs and Fox (1999), the real concern was embedded in the fact that for the vast majority of these students, the science that they had learned was very irrelevant to their lives. Goodrum, Hackling, and Rennie (2001) suggested that there should be a move away from teaching science to the elite to teaching all students by encouraging curiosity, questioning, and facilitating collaborative learning.

These views were also echoed by Millar and Osborne (1998, p. 2005) who believed that the science taught was a "catalogue of discrete ideas, lacking in coherence or relevance". According to Millar and Osborne, the science curriculum in Britain lacked a well-defined series of objectives that clearly stated the scientific capability of the students at the end of their schooling and beyond. They also went on to add that for those who were successful in the subject, the level of the understanding of the knowledge which they possessed did not equip them to effectively and confidently deal with everyday situations in life.

b) Teaching and learning of science is not always centred on enquiries, investigations that lead to the construction and testing of ideas that are connected with the natural world (Goodrum, Hackling, & Rennie, 2001).

Goodrum, Hackling, and Rennie (2001) pointed out that in some primary schools, science was not taught at all. However, if it was taught, it was more student-centred and activity-based. The latter led to a high level of student satisfaction. On the other hand, in high schools, many students were disappointed because the science taught was neither relevant nor engaging. The content did not appear to connect with their interests and experiences (Goodrum, Hackling, & Rennie, 2001). About one third of the secondary students said that the science did not address their concerns and one respondent believed that secondary schools "put out the fire of desire" that was "lit in primary schools" (Goodrum, Hackling, & Rennie, 2001, p. 86).

Millar and Osborne, (1998, p. 2005) observed a similar trend in Britain and they reasoned that such a response could not be wholly accounted for by the onset of adolescence. Goodrum, Hackling, and Rennie's (2001) report also noted that teaching and learning methods appeared to be dominated by traditional methods such as chalk and talk teaching, copying notes off the board and cookbook practical lessons which offered little challenge or induced excitement in the lessons. This was reflected in secondary students responses in which 61% claimed to have written notes every lesson and one third of the comments in the open-ended responses requested for more practical and hands-on work (Goodrum, Hackling, & Rennie, 2001).

According to Millar and Osborne (1998), in Britain the present curriculum has maintained its mid-twentieth century emphasis that was a diluted version of the 1960's GCE curriculum. They pointed out that school science had failed to sustain and develop the wonder and curiosity of natural world amongst young people. According to Schmidt (as cited in Goodrum, Hackling, & Rennie, 2001, p. 7) the curriculum taught was "a mile wide and an inch deep" because it did not place sufficient emphasis on the remarkable intellectual achievement science concepts and ideas represented and how it transformed the world (Millar & Osborne, 1998, p. 2005).

Despite the increasing availability of ICT in schools, 67% of the students had never used computers in their schoolwork and 54% had never looked for information on the Internet at school (Goodrum, Hackling, & Rennie, 2001). Fewer than 10% of the secondary science teachers used alternative teaching methods such as projects, worksheets, ICT, discussions, excursions, and text-based tasks in their teaching routines. Interesting comments from the survey respondents included (Goodrum, Hackling, & Rennie, 2001, p. 86):

> Rote learning and writing is used as a means of crowd control…there are still plenty of tertiary educators and science researchers who talk about academic rigour and mean more rote learning.

Sadler (2002) suggested that one of the ways in which science could be made more interactive and interesting was by developing an innovative and interactive website such as the *Bright MindsTM* web site which engaged students in different ways.

c) Assessment does not serve the purpose of learning and is not consistent with and complementary to good teaching (Goodrum, Hackling, & Rennie, 2001).

Millar and Osborne (1998) pointed out that the science curriculum in Britain had too much summative assessment, which focused on students' ability to recall. This assessment had very limited connection with the actual scientific knowledge and skills that the students needed in a real life situation. What needs to be noted is that a student with a poor ability to recall is labelled a failure in the present system, yet he or she may shine later in life where they are able to apply other problem solving skills to real life situations without any difficulties. Society values and rewards those who can apply themselves in real life situations rather than those who may be excellent at recall. Millar and Osborne (1998, p. 2029) did not believe that the existing forms of assessment were "sufficiently representative of the skills and competencies that society wishes science education to develop". Evaluation and assessment should be more than merely marking answers right and wrong.

The Australian curriculum was assessment-driven, content-based and focused religiously on deadlines (Goodrum, Hackling, & Rennie, 2001). Once students became aware that their assessment was driven by the content, they channelled their energies towards it. Consequently, in many classrooms, students tended not to focus on alternative tasks unless it formed a part of their summative assessment. Goodrum, Hackling, and Rennie (2001) reported that in less than 20% of the classrooms, alternative assessment techniques (e.g., oral reports or creative/dramatic presentations, homework, observations as an assessment method, and portfolios or work samples) were used. On average, tests represented 55% of the weighting of the assessment and students had to remember a lot of facts (Goodrum, Hackling, & Rennie, 2001). More variations to assessment techniques' such as the inclusion of practical tests should be considered. Such tests are seen as the most appropriate method for assessing problem solving and science process skills (Meng & Doran, 1990).

In Australia, the quality of formative assessment and teacher feedback on student progress also varied. Only 7% of high school students were given a quiz to see how they were going in every lesson and 16% participated in formative tasks once a week (Goodrum, Hackling, & Rennie, 2001). It was also interesting to note that 23% of the student population had never seen such tests and almost one third had never received any feedback from their teachers on how they were going in science (Goodrum, Hackling, & Rennie, 2001).

Some educational psychologists have also questioned the present approach to assessments in schools. As pointed out by Gardner (1992), our society had embraced formal testing techniques to an excessive degree. Traditional assessment methods utilized tests that were biased towards linguistic and logical-mathematical intelligences and consequently other human intelligences were either overlooked or ignored. Gardener (1992, p. 85) referred to Jeneks, who pointed out that while the school was "supposed to be a preparation for life, formal testing alone is an indifferent predictor for success once a student has left school".

Outcomes based education has the potential to address some of the concerns provided all teachers willingly embrace the approach. The present assessments tasks probably place too much emphasis on what students learnt, rather than on what they have been taught. Outcomes based education was a learner-centred approach, which occurred in stages and placed an emphasis on real-life contexts.

d) The teaching-learning environment does not induce enjoyment, fulfilment, and ownership because it does not engage students in their learning (Goodrum, Hackling, & Rennie, 2001).

The use of a variety of teaching methods and approaches which have a potential to influence the pace of learning, should be incorporated in classrooms (Millar & Osborne, 1998). Such initiatives should be designed so that teachers were enabled to match the classroom work to the needs and interests of the learners. Student interest and enjoyment in subjects can also be enhanced through "fun" activities and by conducting lessons in various environments. Goodrum, Hackling, and Rennie's (2001) research showed that more than 90% of the science students had never been to a zoo, museum or science centre (or places like these) or heard visiting speakers talk about science.

In their research, Goodrum, Hackling, and Rennie (2001, p. 121) reported that for students, science was "neither too easy nor too hard", yet despite this they did not enjoy science often. Another important finding of their research was that in Australia, the amount of time that was allocated to teaching science varied from state to state. According to Lokan, Ford, and Greenwood (1996), time has been found to be a significant variable that influenced learning. The time allocated to science in the compulsory years of schooling ranged from 150 to 240 minutes (Goodrum, Hackling, & Rennie, 2001). Science was considered to be the third most significant subject in school, yet despite this, Goodrum, Hackling, & Rennie (2001) found that many teachers believed that it was given a low priority in an overcrowded curriculum.

The impact of the low priority of science in schools has already been observed in an international study. According to Goodrum, Hackling, and Rennie (2001), two Australian states which had the lowest relative performance in *The Third International Mathematics and Science Study* (TIMSS) science tests also had the lowest time allocated to science. Apart from effecting learning outcomes as demonstrated in this instance, lack of time in lessons also had an impact on the quality of lessons because teachers were always under pressure to finish the content. Hence, where time was a limiting factor, science lessons with variations were seldom taught.

According to the Working Party of the National Committee for Physics (Australian Research Council, 1993), while physics formed the basis all of the sciences and technologies, trends locally and internationally suggested that it was often not too well taught. There was further concern amongst the Australian Physicists that the quality of secondary education in physics had been in "serious decline for a long time" which was having a "deleterious impact on the quality of the graduates" (Australian Research Council, 1993, p. 49). Such a judgment was based on the level of the knowledge possessed by incoming university students in Australia and overseas. The Working Party of the National Committee for Physics (Australian

Research Council, 1993, p. 49) also pointed out that "one of Australia's greatest assets, the excellent scientific education system of the late 1960's and early 1970's" had been destroyed by the new approaches to teaching. With conflicting opinions such as this, teachers often have a dilemma in terms of which way to lean.

4.2.2 The diminishing enrolments in science subjects

As highlighted in the previous paragraph, most students in the survey conducted by Goodrum, Hackling, and Rennie (2001) did not find science easy or hard. This observation was also made by the National Assessment of Educational Progress, which produced *The Nation's Report Card* (Campbell, Hombo, & Mazzeo, 2000). This organization has been the only one that has monitored academic achievement of American students aged 9, 13, and 17 years in mathematics, science, and reading since 1970. According to this report, mean scores in science for 17-year-olds have followed a parabolic path with the minimum observed in 1982. The report noted that the mean in 1999 was less than the mean obtained in 1969. A similar trend was observed in mathematics; however, the mean scores were consistently marginally higher ever year in mathematics than science. For the 13-year-olds, the science mean fluctuated, but overall it maintained a near flat line over 30 years. Scores in science have been comparable to mathematics, which further confirms that the level of difficulty in science has not been an issue. Science did not become progressively any harder over the years. Despite this, enrolments in science have diminished over the years, which suggests that there were other mitigating factors.

From the mid 1970's, educational authorities have made a more concerted effort to propose solutions to address relevant concerns in science (Sampson, 1989). The *Australian Science, Technology and Engineering Council* (ASTEC) noted that the number of students enrolled in physics courses at tertiary level declined (as cited in ARC, 1993). Consequently, this led to fewer students who graduated with a physics major. In 1984, the Dircks report pointed out that girls were "disadvantaged in their career prospects" as a result of "their attitude to science and their choice of subjects" (Australian Science Teachers Association, 1987). A national symposium was held later that year which concluded that science courses were not addressing "the needs, interests and abilities of many students" and there was a "low participation" of females in science and science education. In 1986, the Commonwealth Schools Commission released its interim report in which it was pointed out that there were complex factors within the mathematics and science curricula in schools that prevented girls from continuing and excelling in these subjects (Australian Science Teachers Association, 1987). These reports formed the basis of the policy on Girls and Women in Science Education in 1987. However, have initiatives such as these made an impact?

According to Dekkers and De Laeter (as cited in Goodrum, Hackling, & Rennie, 2001), while the number of students finishing school with year 12 qualifications had increased from 30% (of the year eight population) in 1970 to 72% in 1995, the proportion of students enrolled in science subjects (physics, chemistry, biology, and geology) in terms of the cohort dropped consistently from 1980 to 1998. Has the implementation of the new initiatives, in science transformed the situation from bad to worse? Other interesting trends in Dekker and De Laeter's data (Goodrum, Hackling, & Rennie, 2001) compiled from 1980 to 1998 on enrolments in upper secondary science subjects in Australian schools were:

- The number of students who were enrolled in alternative science courses such as Environmental Science, General Science, Marine Science, Physical Science, Science for Life, and Sports Science increased almost threefold.
- Physics was still a male dominated subject whereas Biology has always been dominated by females. The trend in Physics has been observed for more than 20 years (McKittrick, Mulhall, & Gunstone, 1999). In 1980, while the ratio of boys to girls in a Chemistry classroom was 2:1, by 1998 this ratio was almost the same.
- The proportion of males and females who enrolled in science subjects also declined. For instance, while 14% of the entire female population in the Year 12 cohort enrolled in Physics in 1980, this dropped to 10% in 1998. Alarmingly for boys, this percentage dropped from 45% in 1980 to 27% in 1998.
- While the size of the Year 12 cohort doubled between 1980 to 1999, the percentage of the student population enrolled in science subjects dropped: Biology (-25%), Chemistry (-13%), and Physics (-11%).

The figures confirmed that the enrolments in the physical sciences were declining. Apart from Chemistry, the composition of the classrooms in terms of gender had remained relatively unchanged in the past two decades. These figures confirmed a view held by Goodrum, Hackling, and Rennie (2001) that disenchantment with science was reflected in the declining numbers of students who took science subjects in post- compulsory years of schooling. It had also effected the participation of boys and girls. Others contributory factors included negative experiences of science in lower secondary years and changing university requirements for tertiary courses (Goodrum, Hackling, & Rennie, 2001). As pointed out earlier, boys enrolled in the physical sciences which appeared to reflect their traditional view of work (Cortis & Newmarch, 2000). However, if fewer boys remained at school after the compulsory years, then it would be reasonable to assume that enrolments in subjects like Physics and Chemistry would decrease.

4.2.3 The widening gap in the academic achievement of boys and girls

Irrespective of how the present day education system is viewed, academic outcomes are probably one of the significant aspects of any educational program. How the learners in an educational system compare with other learners in similar situations is always a significant issue. The *International Association for the Evaluation of Educational Achievement* (IEA) was a major study of student performance in 45 countries. It measured student achievement in mathematics and science in middle primary, lower secondary, and upper secondary. The findings of this study drew attention from individuals at the highest levels of government. The former USA President Bill Clinton was probably not too happy with the performance of the American students after seeing their results. He was quoted as having said that, "...there is no excuse for this" (Gibbs & Fox, 1999).

TIMSS results suggested that in middle primary classes, only Japanese and Korean students performed better than the Australian students at the upper grade level (Goodrum, Hackling, & Rennie, 2001). Similarly, in the lower secondary category students from Singapore, Czech Republic, Japan, and Korea performed better than Australian students at the upper grade level. In the final year of secondary schooling category, Australia was placed seventh out of 16 participating countries. It was interesting to note that students from Western Australia performed significantly better than students from all other states in the primary and lower secondary categories. This result placed them amongst students from the top performing countries (Goodrum, Hackling, & Rennie, 2001). At an international level, the results from TIMSS suggested that the performance of our science students was comparable.

Given this assurance, are boys and girls performing as well as each other? For a few decades, concerns have been expressed about the performance of boys and girls in science subjects. This has since led to numerous research initiatives. For instance, Tobin (1987) pointed out that girls were not achieving as well as boys in science and one possible reason was the way in which the subject was taught. His research showed that boys tended to dominate whole class interactions and laboratory activities. This enabled them to participate in thinking through responses to cognitively complex questions to a much larger extent than girls (Tobin, 1987). Girls on the other hand were able to engage themselves in "individualized activities in a more sustained manner than males" (Tobin, 1987, p. 40). Larkin (1991) suggested that equal opportunity programs were of limited use unless the issue of harassment of female students by their male counterparts was addressed.

The issue of single sex classes was addressed in many studies with "a mix of passionate conviction" and produced "rather ambiguous research results" (Gill, 1992, p. 1). In studies reported by Spear and Rowell (as cited in Sampson, 1989), the bias of science teachers towards boys undermined the achievement of girls in science. According to Sampson (1989), early studies showed that boys performed significantly better than girls in co-educational state schools. She questioned the extent to which the behaviour and attitude of boys could be tolerated as it appeared to usurp the learning rights of girls. Rowe (2000) supported Sampson's research and pointed out that girls did better in single sex-classes. Researchers such as Shaw, Ormond, and Spender (as cited in Gill, 1989) believed that the girls were most likely to develop to their full potential when they were educated in an environment from which boys were absent. On the other hand, Dale (1969) believed that mixed schooling was the best way of providing optimal adjustment to life.

Despite the pre-dominance of mixed schooling in all states, girls have outperformed boys academically in all science subjects. Jordan (1995) pointed out that "fighting boys" who resisted school demands were seen as heroes whereas the "good boys" who conformed to the requirements of the school were viewed as "whimps" or "sissies". According to Biddulph (1997, p. 2), "Today it's the girls who are more sure of themselves, motivated and hardworking...". While this may be the case, there was still serious concern about how girls chose their school subjects and how they marginalised "themselves from new technological skills required for the twenty first century" (Gilbert, 2001, p. 6).

In Queensland, students in years 11 and 12 chose either board or school subjects (or a mix of the two groups of subjects). Students who complete the prescribed number of board subjects receive an *Overall Position* (OP) which is used by tertiary institutions to select students for courses. OP's range from 1 (highest) to 25 (lowest). The OP's are determined from two measurements. Firstly, the performance of students relative to the others in the board subjects in which they are enrolled, is determined. The performance of the students in the *Queensland Core Skills* (QCS) Test is the second important measurement. Every OP eligible year 12 students sit for the QCS test. The individual result in this test contributes to group results that are used to compare groups of students across areas of learning and schools. The performance and enrolment data for year 12 Physics, Chemistry, and Biological Science in 1998 and 2000 (Table 4.1) in Queensland reveals that the enrolment figures are no different from results reported elsewhere (section 4.2.2).

Table 4.1

Enrolment and Performance of Boys and Girls in Year 12 Physics, Chemistry, and Biological Science in Queensland in 1998 and 2000.

Measure and variable	Statistics			
	1998 #		2000##	
	Boys	Girls	Boys	Girls
Physics				
Number enrolled	4532	2099	4567	1963
Percentage enrolment in terms of total enrolment	39%	15%	38%	13%
Mean Overall Position (OP)	9.75	7.33	10.2	7.32
Mean Queensland Core Skills Total Score (QCS)	141.3	148.5	135.1	142.1
Chemistry				
Number enrolled	4324	3818	4475	4212
Percentage enrolment in terms of total enrolment	37%	27%	36%	28%
Mean Overall Position (OP)	9.65	8.42	10.3	8.69
Mean Queensland Core Skills Total Score (QCS)	141.7	144.1	134.6	138.9
Biological Science				
Number enrolled	4220	6961	4269	7444
Percentage enrolment in terms of total enrolment	36%	49%	35%	49%
Mean Overall Position (OP)	13.3	11.7	13.4	11.7
Mean Queensland Core Skills Total Score (QCS)	129.5	131.9	123.9	126.5

Queensland Board of Senior Secondary School Studies (1999)

Queensland Board of Senior Secondary School Studies (2001)

What is noteworthy in the table above is that the girls outperformed boys in terms of OP's and QCS results in physics, chemistry, and biological science in 1998 and 2000. While the proportion of OP eligible students was declining, this decline had been faster for boys than girls (Allen & Bell, 1996). The trend seen in Queensland at Year 12 level is consistent with the observations elsewhere in Australia.

Cortis and Newmarch (2000) for instance, reported that girls performed better than boys across Australia. The average scores for girls in Year 12 assessments were higher in more subjects than vice versa (Cortis & Newmarch, 2000). Interestingly, Cortis and Newmarch (2000) for instance, reported that girls performed better than boys across Australia. The average scores for girls in Year 12 assessments were higher in more subjects than vice versa (Cortis & Newmarch, 2000). Interestingly, Kamperos (2000) found that girls have always outperformed boys proportionately in matriculation subjects since 1884. According to Kamperos, since 1946 girls strengthened their lead by outperforming boys in 16 out of 17 subjects in the *Higher School Certificate* (HSC) examinations. On the other hand, Allen and Bell (1996) pointed out that while the means appeared to demonstrate that overall, girls were doing better than the boys, in the top end of the tertiary entrance scores in Queensland, boys out-performed girls. Matters, Pitman, & Gray (1997, p. 6) believed that the "original question of whether girls have equal educational opportunities has now been replaced with that of whether boys have equal educational opportunities".

In assessing the performance of boys and girls, numerous variables can affect performance. Boys generally chose physical sciences in greater numbers than girls. However, it is also worth considering that their enrollment in these subjects was declining. This factor has been discussed in the previous section. Another factor worth noting was literacy skills, which can have a significant impact on learning outcomes. Cortis and Newmarch (2000) pointed out that the National English Literacy Survey suggested that girls performed better than boys in all five aspects of literacy – writing, reading, viewing, speaking and listening at primary school level. However, boys tended to catch up in Year 8 and then dropped back in Year 10 (Collins, Kenway, & McLeod, 2000). What was even more significant was that the gap in the performance of 14 year old boys and girls on reading tests increased from 3% (girls – 73%, boys – 70%) in 1975 to 8% (girls – 74%, boys – 66%) in 1995 (Marks & Ainley, 1997). The difference in means in 1995 was statistically significant. Multivariate analyses suggested that language background, socio-economic background, and gender were the three factors (in descending order) that effected reading scores. Marks and Ainley (1997) pointed out that fewer than 50% of students with poor literacy and numeracy skills completed school. Low levels of literacy often led to poor performance in subjects which leaned heavily towards assessments that drew on students' mastery of literacy skills (Cortis & Newmarch, 2000).

Head (as cited in Cortis & Newmarch, 2000) believed that the poorer performance of boys was most probably due to their preference for different learning styles pertinent to traditional schooling. Boys preferred interactive and experimental style learning. They tended to do well at short answers and practical tests. Girls tended to do better in assessments such as extended writing. Lerner and Galambos (1996) listed a range of factors such as motivation, curriculum, student teacher, and peer interactions as some of the possible reasons for the disparity in the performance of the two sexes.

4.3 CHAPTER SUMMARY

This study aims to address a number of issues relating to science education in high schools. Indirectly, it also aims to demonstrate how certain aspects of numerous recommendations of *The Status and Quality of Teaching and Learning of Science in Australian Schools* (Goodrum, Hackling, & Rennie, 2001) could be implemented in science education. It also aims to address some of the issues identified by Goodrum, Hackling, and Rennie's (2001) report, which created an actual picture of science that was disappointing and suggested that the quality of teaching ranged from brilliant to appalling.

Specifically this study explores the impact of a blended learning environment on student perceptions, attitudes, and performance in junior science and senior physics. As highlighted in this chapter, despite the increasing availability of ICT in schools (e.g., Dawson, 2001), 67% of the students had never used computers in their schoolwork and 54% had never looked for information on the Internet at school (Goodrum, Hackling, and Rennie, 2001). Fewer than 10% of the secondary science teachers used alternative teaching methods such as projects, worksheets, ICT, discussions, excursions and text-based tasks (Goodrum, Hackling and Rennie, 2001). Goodrum, Hackling, and Rennie's report also noted that the approach to teaching and learning methods was dominated by traditional methods such as chalk and talk teaching, copying notes, and cookbook practical lessons which offered little challenge or induced excitement in the lessons.

This study also attempts to address the issue of formative assessments and teacher feedback on student progress. Goodrum, Hackling, and Rennie (2001) reported that only 7% of high school students were given a quiz to see how they going every lesson, 16% engaged in such formative assessment once a week and 23% of the student population never had such tests. Their research showed that almost one third of the respondents never received any feedback from their teachers on how they were going in science.

Research has shown that while enrolments in science in post compulsory years of schooling have dropped (Goodrum, Hackling and Rennie, 2001) the gap between the academic performance of boys and girls has also widened. Additionally, as discussed earlier in this chapter, Matters, Pitman, & Gray (1997, p. 6) believed that the "original question of whether girls have equal educational opportunities has now been replaced with that of whether boys have equal educational opportunities". In this study, the extent to which web-based learning addresses some of these issues is explored. The impact of a web-based learning environment on the perceptions, attitudes, and performance of boys and girls in junior science and senior physics formed the basis of this research. The next two chapters describe the methods used in this research. Chapter Five outlines the use of the WEBLEI in this study.

CHAPTER 5

THE WEB-BASED LEARNING ENVIRONMENT INSTRUMENT (WEBLEI)

5.1 INTRODUCTION

One key aspect of this research was to ascertain the perceptions of students of a teacher designed web-based learning environment. Perceptions of the learning environment can influence students' attitudes to their subjects which can in turn influence learning outcomes. "Learning is generally assessed through outcomes, but perceptions may again be informative" (Dyson & Campello, 2003, p. 14).

Chapter Two established the background on the field of learning environments and learning environment instruments. Chapter Three discussed aspects of technology in learning. Chapter Four highlighted some issues in science education. In this research, various aspects of the discussion in these chapters overlapped and there was a need to assess the impact of an innovative, web-based learning environment on the perceptions of boys and girls in science and physics. There was a need for a learning environment instrument that could effectively address all relevant areas.

The Web-based Learning Environment Instrument (WEBLEI) was the only suitable learning environment instrument for this purpose. It was developed by Chang and Fisher (1998, 2003) specifically for measuring student's perceptions of their web-learning environments in tertiary institutions. Thus, data on student perceptions in this study were collected by using a modified version of the WEBLEI. The next section discusses the design and development of the WEBLEI and section 5.3 describes its use in this study.

5.2 DESIGN AND DEVELOPMENT OF THE WEBLEI

In the past decade, computers and the Internet have become significant agencies within the learning environment. They have become important in shaping the classroom and home landscapes and consequently the perceptions of the learners of this new variable within their learning environment are important. Research has shown that not all technology-driven interventions in learning lead to positive perceptions. For instance, Elen and Clarebout's (2001) research on an ill-structured innovation on students' instructional and epistemological beliefs suggested that not all authentic tasks in a technologically-rich learning environment generated positive perceptions amongst the participants. Numerous other studies on technology driven learning environments have been done and these have been reported in detail in section 2.4.3.

The development of many learning environment instruments in recent times has been an extension of the design framework of the *Learning Environment Inventory* (LEI) (Fraser, Anderson, & Walberg 1982; Walberg & Anderson, 1968). Each new learning environment instrument has scales and within each scale is a series of items, which help formulate student perceptions for that scale. In the design of the WEBLEI, Chang and Fisher (1998) created four scales and the first three were adapted from Tobin's (1998) work on *Connecting Communities of Learning* (CCL).

The CCL was developed by Tobin (1998) to study the perceptions of maths and science education students enrolled in an asynchronous mode. This program enabled the transmission of text between the learner and the teacher through options such as *Notice Boards, Mail Rooms, DJs, Critical Reviews,* and *Conference Centre*. Tobin (1998) researched the perceptions of practising teachers involved in a distance-learning program who were taught via the Internet. He used a qualitative "hermeneutic" approach in which he considered students' values, priorities and needs to be paramount when defining the variables of the learning environment. He concluded that there were 15 categories that the learners thought, were important in defining an online learning environment. He grouped these categories into three scales: Emancipatory activities, Co-Participatory activities and Qualia. These fitted in with the initial definition of the learning environment proposed by Moos (1974).

Goh and Tobin (1999) found that the three dimensions identified by Tobin (1998) were significant dimensions associated with the CCL. Goh and Tobin went on to suggest the need for the development of a suitable learning environment instrument that would satisfactorily measure students' perceptions in web-based learning environments. Chang and Fisher (1998) extended Tobin's (1998) work and produced the WEBLEI, a learning environment instrument which measured students' perceptions across four scales. Three of the four scales were created using the suggestions of Tobin (1998).

5.2.1 WEBLEI Scale One: Access

Tobin (1998) suggested that three categories of convenience, efficiency, and autonomy were a part of the Emancipatory dimension. He noted that student comments suggested that convenience was an important positive factor provided the technology was "bugs" free (Tobin, 1998). For this reason, the technology had to be efficient. The participants in Tobin's (1998) survey were university students (predominantly females) for whom not having to attend university lectures and still being able to study was a significant factor. Autonomy was another issue because the participants were practicing teachers who needed "to access learning when, where and how" they could (Tobin, 1998, p. 152). He described each of these categories as follows:

- Convenience – students can access learning at times convenient to them.
- Efficiency – not having to attend campus classes allowed for convenient use of time.
- Autonomy – CCL allowed participants to decide when and how to access the curriculum.

In developing the WEBLEI, Chang and Fisher (1998, 2003) transformed the three categories described by Tobin (1998) into eight statements that formed the first part of the learning environment instrument (Appendix A). These eight statements formed a part of the Access scale. Examples of items in this scale included (Chang & Fisher, 2003):

1. I can access the learning activities at times convenient to me.
2. I am allowed to work at my own pace to achieve learning objectives.

5.2.2 WEBLEI Scale Two : Interaction

Tobin (1998) suggested that the Co-Participatory domain was connected to six interrelated categories namely: flexibility, reflection, quality, interaction, feedback, and collaboration. Tobin (1998) pointed out that in his research sample the quality of the understanding developed by the participants reflected their levels of involvement. This in-turn influenced their learning outcomes. While the CCL was developed in an asynchronous environment, Tobin observed that students preferred a synchronous one because it enabled "more immediate interactions with their peers and the instructor" (Tobin, 1998, p. 154). Feedback from diverse sources (peers and instructors) was another advantage provided it was received in a timely manner (Tobin, 1998). While collaboration between all participants was an added bonus in this environment, it did not seem to eventuate readily. One of the participants in Tobin's research wrote:

> I felt that the community was not responding with enough fervour to the issues. I have felt at times that our discourse was not receiving the attention and energy it deserved. I don't blame anyone for this. It's just the result of our very complicated and busy lives.
>
> (Tobin, 1998, p. 155)

Tobin (1998, p. 151) described the six categories of the Co-participation domain as follows:

- Flexibility – allows students to meet their goals.
- Reflection – asynchronous interactions using CCL encouraged reflective interactions.
- Quality – quality of learning reflected the level of activity of the students.
- Interactions – enabled participants to interact with each other asynchronously.
- Feedback – available from the students and instructor.
- Collaboration – enabled participants to collaborate on a variety of activities.

Chang and Fisher (1998, 2003) transformed the six categories described by Tobin (1998) into eight statements that formed the Interaction scale of the WEBLEI (Appendix A). These statements collectively formed the Interaction scale. Examples of items in this scale included (Chang & Fisher, 2003):

1. This mode of learning enables me to interact with other students and the tutor asynchronously.
2. I communicate with other students in this subject electronically (email, bulletin boards, chat line).

5.2.3 WEBLEI Scale Three : Response

Tobin (1998) categorized student responses in the Qualia scale by drawing on the ideas from Churchland's neural network theory. He identified six categories associated with this domain namely: interest, curiosity, enjoyment, satisfaction, simulation, and appreciation. Tobin (1998) found that most of the enjoyment was associated with students' satisfaction in their abilities to link new concepts. In a blended approach, students' confidence and satisfaction was boosted through face-to-face interactions. Tobin (1998, p. 160) noted that the categories of this domain demonstrated the "interconnection of the cognitive and affective dimensions of learning".

Tobin (1998, p. 151) described the six categories of the Qualia scale as follows:

- Enjoyment – associated with academic success and mastery of technology.
- Confidence – associated with successful learning and support for learning.
- Accomplishments – allows students to display their course accomplishments regularly and publicly.
- Success – two dimensions of success pertained to the use of technology and conceptual aspects of the program.
- Frustration – associated with the use of technology and conceptual aspects of the program.
- Tedium – associated with posting and responding to critical reviews on a regular basis in consecutive semesters.

Chang and Fisher (1998, 2003) transformed the six categories described by Tobin (1998) into eight statements that formed the third part of the WEBLEI (Appendix A). They named the third scale, the Response scale. Examples of items in this scale included (Chang & Fisher, 1998):

1. I felt a sense of satisfaction and achievement about this learning environment.
2. I enjoy learning in this environment.

5.2.4 WEBLEI Scale Four : Results

Chang (1999) argued that a web-based learning environment should ascertain learners' perceptions of how the web based learning material was structured and organized, and whether the materials followed acceptable design standards in terms of their scope, interactive capability, and ability to address varied learning styles. They proposed the Results scale which took these into consideration together with the scope of content, aesthetic appeal, web design, and affective aspects of the website. Participants in the initial design of the WEBLEI (Chang & Fisher, 1998) responded to 20 statements e.g.,

1. The learning objectives are clearly stated in each lesson.
2. Activities are planned carefully.

The final version of the WEBLEI had eight statements (2003). Chang and Fisher (1998) took the four scales one-step further. They argued that the four scales were interrelated with each other in an ascending order (Figure 5.1). The Access scale (Scale 1) firmly established access characteristics associated with this mode of learning. Understandably, if students had problems accessing or working comfortably in a web-based environment, then this could influence their perceptions in other scales.

Scale 1 (Access) → Scale 2 (Interaction) → Scale 3 (Response) → Scale 4 (Results)

Figure 5.1. The relationship between the WEBLEI scales.

Once students were comfortable with accessing the learning materials then they could interact with their colleagues and teachers. Hence, the second scale gave an indication of the students' perceptions of the level of interaction. The third scale gave an indication of how they felt about using the online learning environment. The Results scale was probably the most important in terms of the hierarchical arrangement of the WEBLEI. It gave a measure of the results and addressed the issue of whether students felt that they had gained anything from their online learning environment (Chang & Fisher, 2003).

If the desired results were not achieved in an online environment, then through the WEBLEI, researchers had a unique opportunity to analyse the results of the three other scales to establish possible reasons and propose solutions. Data collected via qualitative methods could also be used to supplement the findings of the WEBLEI.

5.3 THE WEBLEI IN THIS STUDY

The WEBLEI was chosen for this study for various reasons. Firstly, it was probably the only learning environment instrument which through the Results scale could effectively generate a picture of students' perceptions of whether they had gained anything from a web-based learning environment. Collectively, the Access, Interaction, Response, and Results scales projected a full picture of the learners' perceptions in such an environment. The data generated by the WEBLEI (together with other qualitative data) had the potential to answer the first four research questions. Secondly, the instrument had already been used and validated in an online tertiary environment (Chang & Fisher, 1998). It had also been found to be a reliable instrument in such an environment. Finally, its versatility and simplicity enabled its easy modification for use for the first time in a high school blended-learning environment.

In this study, the scales of the WEBLEI remained unchanged. Some items were excluded, while most of the others were amended to suit the learning environment of high school students. All four scales had eight items in each.

Table 5.1

Modified Items of the WEBLEI (Scale One - Access Scale).

Item	Description
1	I can access lessons on the Internet at times convenient to me.
2	Lessons on the Internet are available at locations suitable for me.
3	I can access lessons on the Internet on days when I am not in class or absent from school.
4	Lessons on the Internet allow me to work at my own pace to achieve learning objectives.
5	Lessons on the internet enable me to decide how much I want to learn in a given period.
6	Lessons on the Internet enable me to decide when I want to learn.
7	The flexibility of lessons on the Internet allows me to meet my learning goals.
8	The flexibility of the lessons on the Internet allows me to explore my own areas of interest.

The eight items associated with the Access scale are listed in the table above. Each item, though reworded was still connected to the categories defined by Tobin (1998) and described by Chang and Fisher (1998). Examples of the items which were changed significantly included "The on-line material is available at locations suitable for me" and "I can use time saved in travelling and on campus class attendance for study and other commitments." By responding to the items in this scale, students were giving an indication of how well they adapted to such a learning approach. Appendix A presents a list of all items in the modified version of the WEBLEI and those created by Chang and Fisher (2003).

Table 5.2 lists the eight items associated with the second scale. In this study, students' participated in a high school blended learning environment, whereas in the research by Chang and Fisher (2003), all participants were university students who were enrolled in online courses. Consequently, the extent to which students in this research participated in an online environment varied when compared to the respondents in Chang and Fisher's research (2003). While the email option was available at all times, access to chat rooms and the use of the *Forum* (to post answers) varied (this is discussed further in Chapters 7 and 8). Consequently, statements such as "I communicate with other students in this subject electronically (email, bulletin boards, chat line)", "I regularly participate in self-evaluations" and "I regularly participate in peer-evaluations" were re-written to suit high school students (Table 5.2). By responding to the items in this scale, students were giving an indication of what they thought of the quality of the interaction between their peers, instructors, and themselves.

Table 5.2

Modified Items of the WEBLEI (Scale Two - Interaction Scale).

Item	Description
1	I communicate with my teacher in this subject electronically via email.
2	In this learning environment, I have to be self-disciplined in order to learn.
3	I have the option to ask my teacher what I do not understand by sending an email.
4	I feel comfortable asking my teacher questions via an email.
5	The teacher responds to my emails.
6	I can ask other students what I do not understand during computer lessons.
7	Other students respond positively to questions in relation to Internet lessons.
8	I was encouraged by the positive attitude of my friends towards the Internet lessons

The third scale of the WEBLEI corresponded to the Response scale (Chang and Fisher, 2003). By responding to the items in this scale, students' were giving an indication of what they thought of this learning environment. Some of the statements in the original version were amended to suit the students in this study. Statements, which had to be modified, included: "It is easy to organise a group for a project"; "It is easy to work collaboratively with other students involved in a group project"; and "This mode of learning enables me to interact with other students and the tutor asynchronously". The statements used in the modified version of the WEBLEI are listed in Table 5.3.

Table 5.3

Modified Items of the WEBLEI (Scale Three - Response Scale).

Item	Description
1	This mode of learning enables me to interact with other students and my teacher.
2	I felt a sense of satisfaction and achievement about this learning environment.
3	I enjoy learning in this environment.
4	I could learn more in this environment.
5	I can easily get students to work with me on the Internet.
6	It is easy to work with other students and discuss the content of the lessons.
7	The web-based learning environment held my interest in this subject throughout this term.
8	I felt a sense of boredom in this subject towards end of this term.

Table 5.4 lists the items associated with the Results scale, the most significant scale of the WEBLEI. Items in this scale enabled learners to reflect on the question, "What did I gain from this approach to learning?" Some modifications were made to the statements. For example, "Expectations of assignments are clearly stated in my unit" and "Activities are planned carefully" were re-written to suit a blended web-based learning environment in a high school.

Table 5.4

Modified items of the WEBLEI (Scale Four - Results Scale).

Item	Description
1	I can work out exactly what each lesson on the Internet is about.
2	The organisation of each lesson on the Internet is easy to follow.
3	The structure of the lessons on the Internet keeps me focused on what is to be learnt.
4	Internet lessons helped me better understand the work that was taught in class.
5	Lessons on the Internet are well-sequenced.
6	The subject content is appropriate for delivery on the Internet.
7	The presentation of the subject content is clear.
8	The multiple choice test at the end of each lesson on the Internet improves my learning in this subject.

5.4 CHAPTER SUMMARY

In this chapter, the development of the WEBLEI was outlined. The importance of Tobin's (1998) research based on the CCL and its role in the development of the WEBLEI was explained. In the design of the WEBLEI, three of the four scales proposed by Tobin were transformed into a series of items. The three scales were called - Access, Interaction, and Response. Chang and Fisher (1998, 2003) added the fourth scale - the Results scale. According to Chang and Fisher, all four scales were connected to each other.

In this study, the WEBLEI was modified and used for quantitative measurements in this research. The modified version has a total of 32 items with eight in each scale. All students in this research sample completed the WEBLEI. The version of the WEBLEI used in this study is presented in Appendix B. The details of the administration of the WEBLEI are discussed in detail in next chapter. Qualitative techniques were also used in this research which produced a more detailed picture of what the participants thought of their blended web-based learning environment.

CHAPTER 6

RESEARCH METHODOLOGY

6.1 INTRODUCTION

In this research, the impact of web-based learning in a blended learning environment on students' perceptions, attitudes, and performance was studied. Allen and Seaman (2003) defined a blended learning course as one in which 30 to 79% was web-based content. The choice of a suitable learning environment was an essential aspect of this study. In Chapter 5, various aspects of the learning environment instrument used in this study were discussed. This chapter outlines the methodology used in this study which was both qualitative and quantitative.

In many Australian state schools, the implementation of a blended learning environment is more likely to succeed if teachers are themselves involved in the development and maintenance of such environments. There are two reasons for this. Firstly, the design and implementation of schoolwork programs is very much dependent on individual schools. The variation in the work programs between schools is significant, which suggests that a centralized website; the one-size fits all approach is most unlikely to serve the needs of the entire student population at all times. Variation in the work programs usually leads students not only to do different topics but also to cover concepts within topics in a different order and to different depths. Secondly, the cost of websites deigned by professionals is not only prohibitive for individual state schools, but also it shifts the control of resource development to a third party. By developing their own websites, teachers have a far greater control over what their teaching involves. Hence, the development and implementation of *Getsmart* was also aimed at demonstrating that teachers, with minimum experience in ICT, can develop their own websites and engage students productively in meaningful activities. The impacts of this website on students' perceptions, attitudes, and performance in science and physics were the key aspects of this study.

Section 6.2 of this chapter outlines the development of *Getsmart* while section 6.3 details how web-based lessons were implemented. In section 6.4, various aspects of the research sample are presented and in section 6.5 other important considerations in relation to this research are detailed. In sections 6.6 and 6.7, the data collection and analysis methods used are presented. The last section re-focuses the key aspects of the research methodology. The key aspects of this study can be represented as in Figure 6.1.

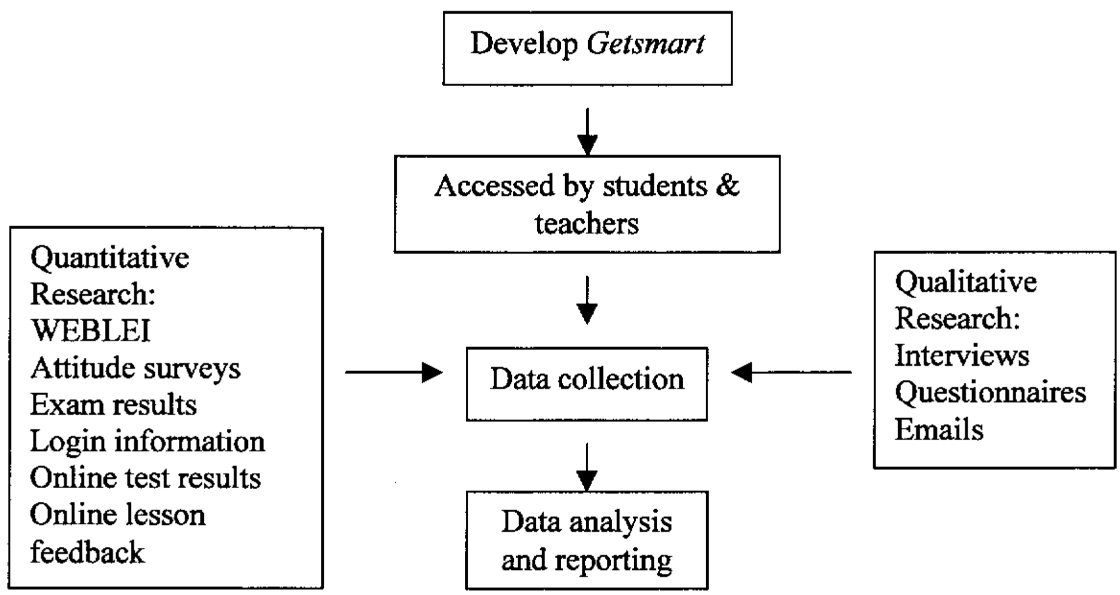


Figure 6.1. Key aspects of the research.

6.2 DEVELOPMENT OF *GETSMART*

Numerous researchers have pointed out the need for ongoing professional development for teachers. Goodrum, Hackling, and Rennie (2000, p. 148) for instance, suggested that teachers' "participation in ongoing professional development" was essential so that they "maintain best practice throughout their career". There is much merit in a suggestion such as this. However, lack of teacher in-service cannot be used as an excuse for the erosion of best teaching practices. Sometimes attitude, aptitude, and self-motivation are more important. The Internet has created unique opportunities for teachers, with almost no professional experience or training in ICT, to use this new technology to vary classroom routines.

Getsmart was developed by a teacher (researcher) with almost no experience or in-service in this aspect of ICT. The development of this website followed good design practices and its evolution was dependent on good research and development ideologies. Instead of immersing students in parcels of web-based interactive tasks, *Getsmart* offered students interactivity in a blended learning environment for one whole term at a time. The sections below discuss its development.

6.2.1 Desired qualities of a good web site

In a traditional classroom, students are generally under the teacher's control. However, their freedom is significantly increased when they log on to the Internet. Once they are logged in, it becomes very difficult for teachers to monitor exactly what the students are doing. As in many web-based environments, time on task is not always equal to the total connection time (Bruckman, Edwards, Elliott, & Jensen, 2000). Brooks, Nolan, and Gallagher (2001) pointed out that students who were poor at self-regulation could easily feel defeated in web-based courses. They noted how self-regulation involved a range of factors which affected students' performance such as their behaviour, motivation, and cognition to fit the task. If students are taught to become self-regulators, they will have a far greater chance of succeeding in such learning environments.

Brooks, Nolan, and Gallagher (2001) suggested that some of the teaching strategies resulted in substantially more positive learning outcomes for students than others. They also believed that the web was changing not only the content of the learning materials but also the way these learning materials were delivered. Brooks, Nolan, and Gallagher (2001) also pointed out that purposeless surfing of the net did not improve learning outcomes, but, when used with the correct teaching strategies, the web supported active learning, mastery learning, cooperative learning, and even passive learning. Such a tool facilitated the creation of a constructivist classroom in which the task of the teacher is to arrange relevant resources, act as a guide to students while they set their own goals and taught themselves (Roblyer, Edwards, & Havriluk, 1997). The design of *Getsmart* actively supported this philosophy.

Brooks, Nolan, and Gallagher (2001) proposed numerous features that websites should have in order to improve learning outcomes. A high degree of interaction was one of their suggestions. Features which promoted interaction included provisions for asynchronous discussion (emails and bulletin boards) and synchronous discussion (chat rooms). They suggested that websites should use:

- hypertext links to enable readers to make decisions about their reading.
- web-based assessment tools such as quizzes and tests.
- visual media such as still images and images in motion.
- a "neat" domain address to identify the website.

Janicki and Liegle (2001) developed WebTAS (*Web-Based Tutoring Authoring System*) which blended parts of instructional design theories and ideas proposed by web researchers. WebTAS incorporated features such as multiple examples and exercises, consistent design, feedback management, and tracking process capability.

The educational value of the website has to blend in with good web design principles. Issues such as the process, interface and site designs, page design, typography, editorial style, graphics, and multimedia were recognized as essential ingredients of a good website (www.webstyleguide.com).

Janicki and Liegle (2001) pointed out that many researchers believe that the current web-based educational tutorials are poor in educational content. This observation suggested that many websites lack a clear educational philosophy. Janicki and Liegle (2001) emphasised the importance of incorporating learning concepts into websites. The initial approach of converting books and lectures into a web format was unsatisfactory because such an approach did not necessarily teach (Janicki & Liegle, 2001; Schank, 1993; Schank, 1998). Schank (1993) also pointed out that many websites merely presented information and data with limited interactive opportunities. While Schank's idea had some merit, any interactive website needs to have some information and data embedded in the pages to put the unit in context.

All these ideas were acknowledged in the development of *Getsmart*.

6.2.2 Features of *Getsmart*

The primary objective was to develop an interactive website that provided students with an alternative learning option. There were three essential ingredients which shaped the design of the website (see Figure 6.2). Firstly, the design of the features was influenced by instructional methods of cognitive apprenticeship (6.2.2.1). Secondly, the website evolved at various stages of the research through user feedback (6.2.2.2). Thirdly, it incorporated feasible aspects of web design ideas (6.2.2.3).

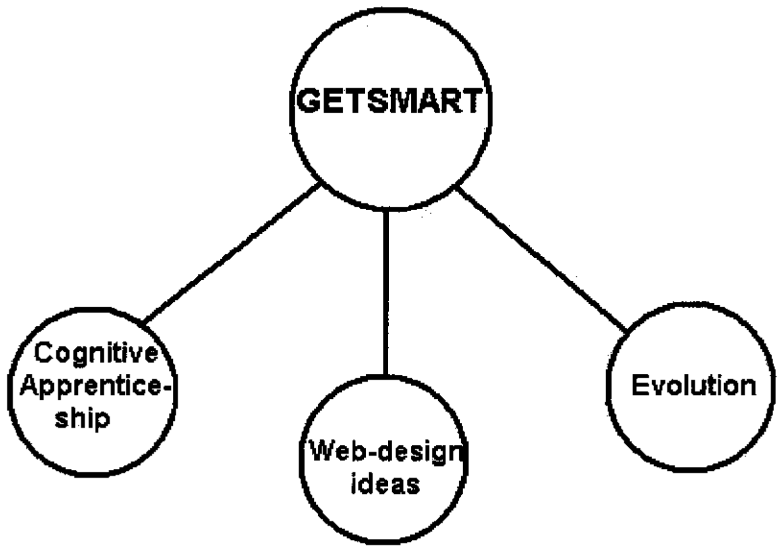


Figure 6.2. Factors influencing the design of *Getsmart*.

6.2.2.1 Cognitive Apprenticeship

> The reason that Dewey, Papert, and others have advocated learning from projects rather than from isolated problems is, in part, so that students can face the task of formulating their own problems, guided on the one hand by the general goals they set, and on the other hand the 'interesting" phenomena and difficulties they discover through their interaction with the environment".
>
> (Collins, Brown, & Newman; 1989, p. 487)

In this study, instead of using the Internet for isolated classroom activities, an attempt was made to design a website with various options that presented concepts that revolved around "real life" situations. While some of the web-based activities displayed aspects of other learning theories, user options revolved around the instructional methods of cognitive apprenticeship. In doing so, the website also attempted to address some of the issues raised by Goodrum, Hackling, and Rennie's (2001) report on science education, for example, making science more relevant and inducing more variety in lessons.

As discussed previously, many existing educational websites were not designed on sound educational theories (e.g., Janicki & Liegle, 2001; Schank, 1993; Schank, 1998). More to the point is the fact that test questions came in a hodgepodge of styles and formats and the publicly available questions were of a poor quality (Schocken, 2001). Pollock and Squire (2001) pointed out that no delivery system had ever revolutionized education and even the Internet had its limitations. It was not to be viewed as the be-all and end-all. Since it has the capability of creating too many options, a good structure in websites is essential. Without a good structure, a web surfer could easily switch off (Pollock & Squire, 2001).

Whitlock (2001, p. 190) also expressed the need for quality web-based stand-alone models and pointed out that what was required was "the development of a plain-language designer's practicum using up-to-date model of instructional design on which to base a development programme for practising course designers." Numerous possible approaches to web-based learning were discussed in Chapter Three. In this study, *Getsmart* was designed on the instructional methods of electronic cognitive apprenticeship (Bonk & Kim, 1998; Collins, Brown, & Newman, 1989; Wang and Bonk, 2001). This approach was chosen largely because practising teachers and students are very familiar with instructional methods of cognitive apprenticeship. Such an approach draws a parallel between teaching methods in a traditional classroom and a web-based learning environment. Hence, it is believed that such a connection would enable both teachers and learners to make a smooth transition.

Cognitive apprenticeship initiates the novice into a community of expert practitioners (Berryman, n.d.) and the model proposed by Collins, Brown, and

Newman (1989) consists of four blocks – content, methods, sequence, and sociology. Such an approach created an effective learning situation in which learners and teachers had different roles. Prior to the advent of formal schooling, the apprenticeship option was the most common means of learning (Collins, Brown, & Newman, 1989). The cognitive apprenticeship model proposed that learners should be exposed to "a variety of methods that systematically encourage student exploration and independence" and teachers should provide scaffolding and gradually "fade handing over control of the learning process to the student" (Berryman, n.d., p. 5). In doing so, teachers involve students in their learning (Collins, Brown, & Newman, 1989). The cognitive apprenticeship model also proposed that "the learning environment should reproduce the technological, social, time, and motivational characteristics of real world situations" with varying levels of difficulty which enabled students to work with their peers in finding solutions to problems as it happened in the real world (Berryman, n.d., p. 5). However, one key aspect of this exercise was to break the problem into parts so that students could learn with it easily.

> Cognitive apprenticeship, as we envision it, differs from traditional apprenticeship in that the tasks and problems are chosen to illustrate the power of certain techniques or methods, to give students practice in applying these methods in diverse settings, and to increase the complexity of the tasks slowly, so that component skills and models can be integrated.
>
> (Collins, Brown, & Newman; 1989, p. 459)

Wang and Bonk (2001) believed that the design of any *Groupware-Based Learning Environment* (GBLE) required learning theories as foundations in order to substantiate the learning effectiveness of the environment. Groupware software facilitates collaboration, communication, and coordination. For their research on case-based learning, Wang and Bonk (2001) developed a system which was underpinned by the principles of *electronic* cognitive apprenticeship. They designed their system on the six instructional methods of cognitive apprenticeship namely: modelling, coaching, scaffolding, articulation, reflection, and exploration. The design of *Getsmart* (Figure 6.3) enabled students to engage in these six methods in addition to the three others proposed by Bonk and Kim (1998). The three additional methods were: questioning, performance feedback or management, and direct instruction.

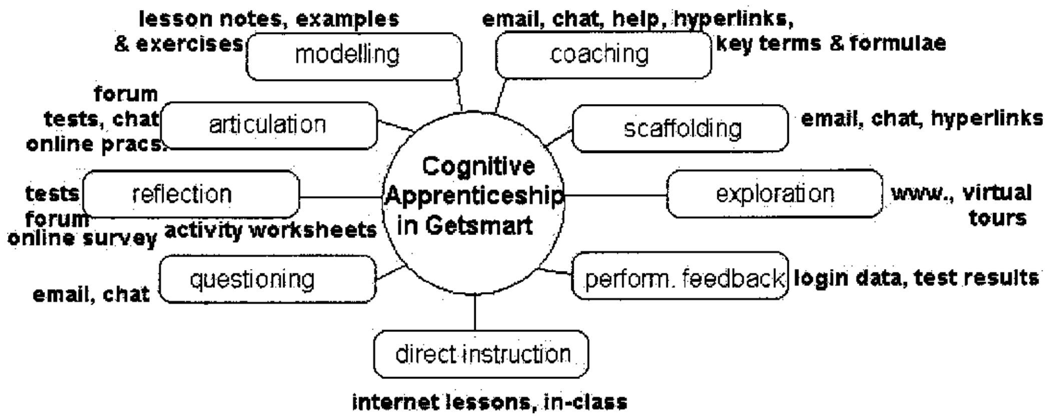


Figure 6.3. The design of *Getsmart* using an electronic apprenticeship framework and learning activities associated with each instruction method.

Modelling

"Modelling provides opportunities for students to observe an expert's practices" and should include "exemplars of how an expert performs the tasks" (Wang & Bonk 2001, p. 131). Within each unit, *Getsmart* had a variety of lessons which focused on the key aspects of the unit. Modelling was achieved in each lesson through the provision of concise notes, definitions, formulae, and explained solutions to exercises.

Students often found problem solving difficult. Therefore, in solving each exercise, there was a consistent layout. It clearly showed a progression of steps essential for problem solving. Each solution was broken into three parts: WHAT'S GIVEN, FORMULA, and WORKING (Appendices E & F). There were web-based activities such as simulations that were closely related to the key concepts (Appendix D). These interactive activities also modelled the type of results students could expect in their experiments. A web worksheet was also designed for each lesson. Each worksheet not only summarised the lesson, but it also contained some thought-provoking questions that formed the basis of future in-class discussions (Appendix H). The web pages were also designed to address an issue raised in Goodrum, Hackling, and Rennie's (2001) report on science education. They noted that science teaching and learning methods appeared to be dominated by traditional methods such as chalk and talk teaching and copying notes off the blackboard. This was reflected in secondary students' responses where 61% claimed to have written notes every lesson. The web pages served as notes which students otherwise would have had to copy in class.

Coaching

Coaching involves support through tasks such as hints, scaffolding, feedback, modelling, and goal setting (Wang & Bonk, 2001). Responses to emails, discussion in chat rooms (see Table 8.1), a list of key terms and formulae (Appendix E, Appendix I), help links on revision pages (Appendix G) and hyperlinks in each lesson provided student support and coaching. Each test page clearly stated what was expected of students, i.e. *If you do not get full marks, repeat the test until you do.* In the optics unit, students were also taught how to draw ray diagrams using *Microsoft Paint* (Appendix M).

Scaffolding

Scaffolding involves support from teachers through suggestions and direct help. A key feature of scaffolding requires teacher-support to diminish as students become more capable of functioning effectively on their own (Wang & Bonk, 2001). In *Getsmart*, scaffolding was provided by the peers, teachers, and through the Internet. The teacher provided support via emails, chats, and direction interaction during Internet lessons. Students also supported each other during Internet lessons and through web-based chats. Saloman, Globerson, and Guterman (1989) pointed out that a computer could provide intellectual scaffolding in the same way that an adult or more capable peer would, provided it was appropriately programmed. In *Getsmart*, the web-based tests gave students results, which were expressed as a percentage, and a computer generated comment which correlated with their performance. These comments were *Excellent, Very good, Average,* and *You have to put in more effort.* According to McInerney and McInerney (2002) feedback should be immediate to keep students on task. This is generally not possible for every student in every lesson in a traditional classroom for obvious reasons, whereas with technology feedback is one click away.

Bell and Davis (2000) investigated the impact of scaffolding in the form of notes and prompts by using guidance software called *Mildred* in a science classroom. They concluded that such software packages improved students' understanding because of their participation individually and in teams. Similarly, the use of *hypertext* enables users to jump from one idea to another (e.g., bookmarks) and hyperlinks allow access to other websites and web pages. Hypermedia linked to multimedia also provides students with temporary support when they need more help with a problem or concept. *Getsmart* made provisions for many of these facilities (Appendices C-N).

Articulation

Articulation requires students to express their knowledge, reasoning, or problem solving skills for questions or issues they are tackling (Wang & Bonk, 2001). Web-based chats and the *Forum* were available for students to express their thoughts and views to the teacher and other students. Questions were posted on the *Forum* on a weekly basis and students were asked to voluntarily post their solutions or other concerns. Students could also email their concerns, worked solutions to problems, and practical reports to the teacher. *Getsmart* did not broadcast student emails for privacy reasons. Students also had the option to participate in web design (Appendix N) which gave them an opportunity to demonstrate their knowledge in specific areas. Tests also gave them an idea of how much knowledge and problem solving ability they had in relation to a concept.

Reflection

Reflection enables students to demonstrate their abilities which can be evaluated (Wang & Bonk, 2001). One of the features of *Getsmart* was the web-based tests (Appendix F, Appendix J) that gave students an opportunity to demonstrate their understanding. Poor performance in these tests was often a sign of a lack of understanding of the concepts associated with a lesson. The *Forum* and web-based chat also enabled students to demonstrate their grasp of a certain concept. In some units, there were downloadable worksheets (e.g., Radioactivity Data Analysis) which were focused on practical activities (Appendix K). Students completed these sheets and handed them to the teacher for comment. According to Goodrum, Hackling, and Rennie (2001), only 7% of high school students were given a quiz to see how they were performing in every lesson and 16% engaged in such formative assessments once a week. It was also interesting to note that 23% of the student population never had such tests and almost one third never received any feedback from their teachers on how they were progressing in science. With *Getsmart,* students were given feedback by the Internet software and by the teacher.

Exploration

Through exploration, students are expected to tackle and solve problems independently (Wang & Bonk, 2001). Goodrum, Hackling, and Rennie (2001) noted that teaching and learning methods appeared to be dominated by cookbook practical lessons which offered little challenge and induced little excitement in the lessons. In their survey, responses from secondary students suggested that one third of the sample wanted more practical and hands-on work.

One of the greatest potentials of the Internet is that it provides students with an opportunity to explore topics in various ways. Such an exploration is generally impossible in the confines of a traditional classroom. Exploration type activities promote deep understanding of concepts (McInerney & McInerney, 2002). Links to other related sites enable students to understand how others have viewed the same concepts and more importantly how they relate to real life situations (eg. crash tests involving automobiles). Once students are aware of the key concepts, they can expand their horizons by performing appropriate searches on the Internet.

> A critical element in fostering learning is to have students carry out tasks and solve problems in an environment that reflects the multiple use to which their knowledge will be put in future.
>
> (Collins, Brown, & Newman, 1989, p. 487)

Getsmart also had hyperlinks to sites, which had excellent applets e.g., Eric Bishop's rocket modeller (http://www.grc.nasa.gov/WWW/K-12/airplane/rktsim.html) and Fu-Kwun Hwang's (http://www.phy.ntnu.edu.tw/java/Reaction/reactionTime.html) reaction time java applet. By embedding applets and simulations in lessons, students had a much greater chance of integrating the knowledge gained from them with existing knowledge. Consequently, students also had an increased opportunity to comprehend the processes and principles which underpinned these simulations (McInerney & McInerney, 2002). Apart from being a "fun way" to learn, simulations produced various other positive outcomes such as increased motivation amongst learners, improved attitudes, and enhanced problem solving skills (McInerney & McInerney, 2002).

Questioning

Questioning is another important aspect of learning with which not all students are comfortable with. Hewitt and Scardamalia (1998) pointed out that in a normal classroom environment the shy or withdrawn students often avoid asking questions. Time was another constraint that prevented even good students from asking questions in a normal lesson. Hence, the email option (Appendix E, Appendix I) in *Getsmart* created an opportunity where students could voice their concerns from the comfort of their homes. During chat lessons and Internet lessons, students also had an opportunity to ask questions on a one to one basis.

Performance feedback and management

Performance feedback and management is another important aspect of cognitive apprenticeship. Goodrum, Hackling, and Rennie's (2001) findings in science education suggested that the lack of feedback to students was an issue (discussed above). *Getsmart* was designed to track student participation. For this reason, it gave students an opportunity to view their login details and reflect on their test results. Subsequently, students were expected to act on the data displayed in their user record (Appendix O). In such environments, it was necessary for teachers to monitor student participation, identify the non-participants and give assistance as appropriate (Tobin, 1998). In this research, login data and web-based test results were written on a database that was linked to *Getsmart.* These two features together with web-based feedback to web lessons enabled effective learner management.

Direct instruction

In a blended teaching approach, the student is not left alone since he or she has an opportunity to engage in direct instruction. The importance of such interaction was highlighted by Gräsel, Fischer, and Mandl (2000) who studied the impact of computer-based self-directed learning in a problem-oriented environment with senior medical students. They concluded that even with advanced learners, instructional designers could not rely on learners to recognise and correct their mistakes when they learnt individually. A blended learning environment created numerous opportunities in the classroom during Internet lessons and at other times when direct instruction could occur between learners and instructors.

6.2.2.2 The evolution of *Getsmart*

Getsmart evolved during the time the research was carried out, largely because of user feedback, observations made by teachers during web-based lessons and improvements in Internet technology. However, when students actively used the website, improvement initiatives were halted to ensure that it did not interfere with the research findings. It was estimated that the researcher put in more than 1,200 hours in the design, development, and maintenance of the website. In addition to this, professional web developers provided a total of another 50-60 hours.

The website was initially trialled with a group of Year 11 Physics students in 2001. In this interim stage, the website had fewer than 10 lessons. Notes, examples, and exercises were the only features of each page. As indicated in Table 6.1, by 2002, the number of features increased to five and by 2003, the website had 14 features and 74 lessons in science and physics.

Table 6.1

Features of Getsmart (2001-2003).

Year and features of *Getsmart*
2001
➢ Lesson pages
2002
➢ Lesson pages with graphics
➢ Multiple choice tests
➢ Email option
➢ Links to other sites
➢ Web-based chat facility
2003
➢ Lesson pages with graphics
➢ Revision page(s) per unit or topic
➢ Key words list per page
➢ Some lessons had downloadable worksheets
➢ *Html* pages replaced by pages written in *asp*
➢ Multiple choice and short answers tests
➢ Email option
➢ Links to other sites
➢ Own domain name
➢ Web-based simulations, movies & experiments
➢ Password login
➢ User feedback capability
➢ Tracking login frequency and test results via a database

6.2.2.3 The design of *Getsmart*

According to Saddik (2001), there are three key participants in the design of education websites. These are the web developer, the educator, and the learner. Many school websites can only be economically viable if the teacher performs the dual role of web developer and educator. As pointed out by Saddik (2001), the design of any website should endeavour to cast the learner as an active participant. He believed that the ancient Chinese proverb "Tell me and I forget, Show me and I remember, Involve me, and I understand", still has its place in the multimedia age.

As discussed in Chapter 3, many students are switched off science as soon as they commence high school (Goodrum, Hackling, & Rennie, 2001). These views have also been shared by other researchers. For instance, in a newspaper article, O'Leary (2001, p. C08) wrote:

> Rather than inspiring pupils to improve people's lives or make discoveries, the curriculum restricted them to dull questions about the bouncing of squash balls or the dissolving of sugar, Professor Reiss said.

While websites open new doors for students, their design and focus have to adhere to the requirements of the "work program" designed by the schools. There is always a limit in terms of how adventurous or innovative teachers can become with such initiatives. Irrespective of how schooling is viewed in modern times, at the end of a term or semester, students have perform to succeed and teachers are accountable for any shortfall in their performance.

Hence, pages in *Getsmart* were designed so that the educational value reflected the requirements of the subject work program. As discussed above the website evolved as the research progressed. The possible impact of these developments is taken into account when the results of this research were presented. Subsequently, the results obtained in 2002 and 2003 are presented separately in the results section.

Target audience

The website was aimed at students in years 10, 11, and 12. Hence, the ease of use was central to its development. The lessons were designed so that they would keep students on task and could be completed within a normal school period. Each school period lasted for a maximum of 31 minutes (it generally required 3-5 minutes for students to login into the school computers).

Software and hardware requirements

The development of the web pages was primarily from *Microsoft Front Page*. Various *file transfer programs* were used to upload pages onto the server. User data were stored using *Microsoft Access*.

Splash page

Getsmart had its own "neat" domain address u2cangetsmart.com. This enabled students to remember the web address easily. Quality graphics together with an introduction to the website featured on the splash page (Appendix C). Accessibility to the website was through a username and password. New users could register by clicking a hyperlink on this page. Hence, students who could not recall their username or password, could still register as new users and access the website.

Contents page

Students could access the rest of the website through the contents page or the navigation bar (Appendix D). This page listed all the contents of the website plus links to other useful sites and was updated as new pages were added. The *CHECK MY RESULTS* and *CHECK MY LOGIN HISTORY* links were very useful for students as they gave them an opportunity to track their own user information and monitor their progress.

Lesson Pages

Each page highlighted key aspects of a topic and was closely related to the work done in class, the work covered in the textbook, and the requirements of the work program. The layout was kept uniform throughout the website (see Figure 6.4) ensuring that students did not have to re-discover the steps of using the web pages each time they logged in.

The header and the navigation bar remained fixed irrespective of the lesson to which students logged in. Students also could access any of the lessons on the website or explore other options (such as news and support) by using the navigation bar. The left hand column had various features which were directly related to the lesson such as key terms and formulae, related topics, useful links, email link (to the teacher) and links to get to the home or contents page.

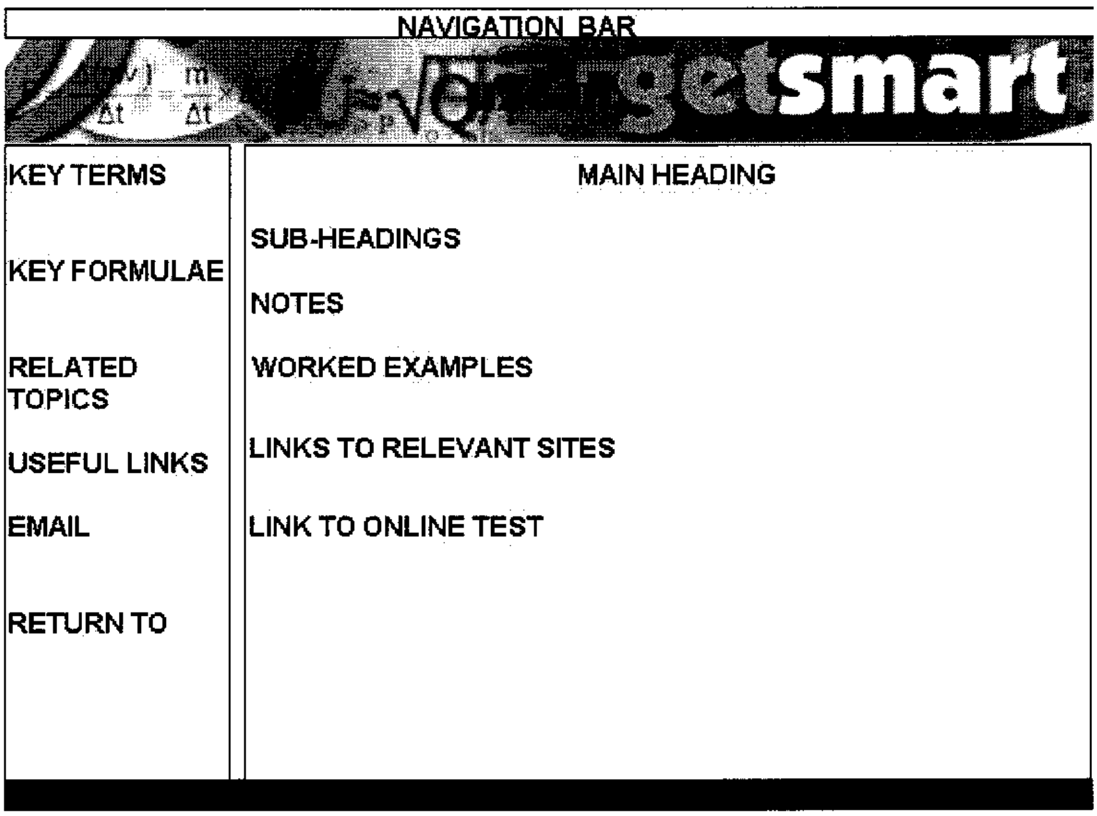


Figure 6.4. *Key features of the lesson page.*

The bulk of the page was allocated to notes, diagrams, figures, and worked examples. Thought provoking questions also were used throughout the page (Appendix D). Links to other websites were intertwined with the content, for example, the lesson page on inertia was linked to the *Physics Classroom* website (http://www.physicsclassroom.com/mmedia/newtlaws/cci.html) which emphasized the importance of seatbelts in cars. In some instances, such a step was essential because certain organisations are better equipped to produce websites which are more effective in demonstrating concepts. For example, *NASA* websites were also very useful in demonstrating concepts associated with space travel (http://kids.msfc.nasa.gov/Rockets/shuttle.asp). At the end of each lesson there also was a link which took students to the test page. *Verdana* font size 12 was used in contrasting colours throughout the lesson pages to emphasise the key aspects of a lesson.

Test and revision pages

Most pages were linked to a multiple-choice test (Appendix E, Appendix F, Appendix I, Appendix J). These tests provided instant feedback to the user. Feedback to the tests did not specify which questions were wrong for two reasons. Firstly, students had to understand that there was more to an answer than merely clicking on an A, B, C, or D (e.g., multiple- choice tests). Secondly, a wrong answer was meant to encourage the student to find the correct answer. It was purposely designed in this manner to encourage interaction. Students could review their answers themselves or discuss it with their peers or the teacher. Such interactions occur through emails, *Forum*, chat, or discussion in class or during Internet lessons. The tests were usually written with an increasing level of difficulty. The results of these tests were written in a database file which could be accessed by students and teachers.

Online lesson feedback

Once the test was completed and students were given their results electronically, they were then asked to participate in a web-based survey of one question. Their participation in this survey was optional. The question was: *How would you rate the lesson page and the test?*. The answer options were *excellent, very good, average, needs improvement* and *a waste of time*. Their responses were written to the database.

Each unit had a revision page (Appendix G, Appendix L). It had a variety of open-ended questions which provided students with an overview of the unit. In some of the pages, there were bookmarks with questions that appeared as a help link. The layout of this page was similar to a lesson page. The left column had all the key formulae and key terms listed together with hyperlinks to all topics in the unit and other useful websites developed elsewhere.

Activity pages

Activity pages were designed to demonstrate a concept that would generally be conducted as an experiment. While these activities did not replace classroom practicals, one of the purposes they fulfilled was that they presented feasible outcomes of such activities (Appendix K, Appendix M). For instance, students could see the data generated by a radioactive source. These data were then used for analytical purposes such as determining the half-life and the decay constant of the radioactive isotope. Experiments using radioactive sources are not possible in schools (because of health and safety issues); for this reason such activities were useful in demonstrating the relevant concepts. In these lessons, students could also download a lesson worksheet which was completed and submitted to the teacher for feedback.

Interaction options: email, chat, *Forum*

Interaction options in Getsmart demonstrated one of the ways in which Vygotsky's idea of zone proximal development can be applied to an Internet-based environment. Even at a distance, a student was not alone. The website itself provided a certain degree of scaffolding (as discussed earlier in this chapter). However, the student could still be supported via the options available on Getsmart. The email provided a direct interaction between the teacher and the student. The chat and *Forum* options were accessed via Education Queensland's Learning Place and were only available to senior physics students. These options enhanced the possibilities for interaction.

The *Forum* acted like an electronic noticeboard. The teacher posted questions and students posted their answers. The chat room was only operational after school at specific times. The teacher acted as the moderator and the chat room was only accessible to students if the teacher had already logged in.

Multimedia and Lesson cost

According to McInerney and McInerney (2002) multimedia presentations are both attention-getting and motivating for the learners. Multimedia has been defined as forms of media that includes video, audio, text, and images (Brooks, Nolan, & Gallagher, 2001). Lessons on Getsmart had diagrams and digital images to clarify aspects of the lesson content. Most of the diagrams were drawn using Paint and were saved in either Graphics Interchange Format (GIF) or Joint Photographic Experts Group (JPEG) formats. Digital photos were saved in the JPEG format while Digital Movies were produced using Microsoft Windows Movie Maker and saved in the Windows Media Video (WMV) format.

The students who participated in this research had to pay to access the Internet at a cost of 20 cents per megabyte. The school where this research was centred levied this cost to all users. Hence, all web lessons were designed in such a way that a student had to spend no more than 20 cents to successfully complete all aspects of the lesson (including downloading movie files). Most lessons cost between six or seven cents.

Ethical and Safety Issues

Permission was sought (wherever possible) from web developers and relevant copyright holders if Getsmart was linked to their websites. In view of privacy issues, all email addresses of students were kept confidential. The chat room was developed so that students could only access it when the moderator (researcher) had electronically logged in.

6.3 IMPLEMENTATION OF WEB-BASED LESSONS

Lessons were designed in senior physics and junior science. Research data were collected from Year 11 Physics students in Term 2 (2002), Year 12 Physics students in Term 3 (2002), Year 10 Science students in Term 2 (2002), Year 10 Advanced science students in Term 2 (2003) and Year 12 Physics students in Term 3 (2003). Data were collected either at the end of a term or after the students had completed a unit of work. Table 6.2 lists the web-based lessons that were designed for these students.

Table 6.2

Web-based Lessons on Getsmart Designed Specifically for Year 10 Science and Years 11 and 12 Physics Students.

Topic	Subject & Year Level	Web-based lessons
Road Science	Science Year 10	➢ What is speed? ➢ What does a graph tell us? ➢ What is acceleration? ➢ Reaction time and reaction distance ➢ Inertia, Force, mass and acceleration ➢ Revision 1 ➢ Revision 2
Space Travel	Science Year 10	➢ How does a rocket work? ➢ Space Exploration ➢ Space Travel Revision
Genetics	Science Year 10	➢ Introduction to Genetics (Lesson 1) ➢ Inheritance (Lesson 2) ➢ Predicting Crosses (Lesson 3), ➢ Pedigrees (Lesson 4) ➢ Blended Genes (Lesson 5) ➢ Sex-Linked Genes (Lesson 6) ➢ The structure of DNA (Lesson 7)
Motion	Physics Year 11	➢ Scalars & Vectors ➢ Speed & Velocity ➢ Acceleration ➢ Equations of Motion ➢ Motion graphs(1) ➢ Motion graphs(2) ➢ Application of motion concepts ➢ Free falling objects ➢ Projectile motion ➢ Circular motion ➢ Non-uniform circular motion ➢ Review questions (1) ➢ Review Question(2)

Energy & Momentum	Physics Year 11	➢ Momentum ➢ Conservation of momentum ➢ Momentum Problems(1) ➢ Momentum Problems(2) ➢ Kinetic Energy ➢ Potential Energy ➢ Kinetic and Potential Energy combined ➢ Work and Energy ➢ Forces(1) ➢ Forces(2) ➢ Review Questions
Optics	Physics Year 11	➢ Plane mirrors ➢ Reflection in a curved mirror ➢ Ray diagrams (concave mirrors) ➢ Ray diagrams (convex mirrors) ➢ Mirror formula ➢ Practice ray diagrams (mirrors) ➢ Mirrors chapter summary ➢ Refraction ➢ Convex Lens ➢ Concave Lens ➢ Practice ray diagrams (lens) ➢ Lens formula ➢ Optics revision
Electronics	Physics Year 12	➢ Semi-conductors ➢ More on doping ➢ Common electronic components ➢ Capacitors ➢ Diodes ➢ Light Dependent Resistors in action ➢ Capacitors in action ➢ NPN & PNP Transistors ➢ Logic Gates ➢ Electronics Revision

Atomic Physics	Physics Year 12	➢ History of the atom ➢ The hydrogen atom ➢ Frank-Hertz Experiment ➢ Radioactivity ➢ Radioactivity data analysis ➢ Binding Energy ➢ Atomic Physics Revision

Each web-based lesson (Appendix E, Appendix I) focused on a concept or concepts with suitable examples. After reviewing the lessons students had to complete a test which gave them an indication of how many questions they answered correctly. This also provided them with an idea of how well they understood the web-based lesson. After completing a unit series of lessons, they could also do a revision exercise (Appendix G, Appendix L). In junior science classes, students were also given a photocopied worksheet, which not only kept them on task but also served as a substitute for copying notes off a blackboard (Appendix H). In senior physics classes, students had the option of downloading worksheets that were completed and handed in for feedback from the teacher (Appendix K). In some instances, students were expected to collect and interpret data generated on some of the pages.

6.4 RESEARCH SAMPLE

This study was conducted at a Queensland State High School, chosen because the researcher was a maths-science teacher at that school. Hence, it was believed that the implementation of web-based learning and data collection would be more manageable. Additionally, such an approach enabled the presentation of the research findings as a case study. The school had a population of approximately 1,300 students in Years 8 to 12. It had in excess of 250 computers that had Internet access in eight rooms. Students studying computer-related subjects had priority for using these machines. Other classes could access computers through negotiation with teachers who were timetabled in these rooms or use computers when no classes were timetabled at the required times. The availability of computers was an issue of concern in this study.

School examination results of all students who participated in this study were used for data analysis. All completed surveys were used for qualitative and quantitative data analysis. If any surveys or exam results were excluded, then these have been accounted for and explained in the results section. Sample sizes varied and its impact on the results was also considered when they were interpreted. As outlined above, this study focussed on five different groups – Senior Physics (Years 11 & 12), Year 10 Science and Year 10 Advanced Science.

Senior Physics

Four groups of physics students were targeted with class numbers ranging from 16 to 25. The Senior Physics course in Queensland school runs over two years, i.e four semesters. Each school formulates its own work program, which must be approved by the Queensland Studies Authority (previously known as the Board of Senior Secondary School Studies). A panel of teachers appointed by the studies authority monitors assessment undertaken by the students. The physics work program in each school is based on the nine syllabus topics. In this school, at the completion of each unit, there was an assessment. These were conducted across three performance dimensions: knowledge, science processes, and complex reasoning skills. With the exception of the assessment in complex reasoning skills in Semester 1 (Year 11) all other assessments were summative.

Year 10 Science

The Year 10 Science course was designed by the school that was based on the Queensland Junior Science syllabus. Students were assessed upon completion of a unit of work that usually reflected two or three chapters of work covered from their textbooks. The assessment was in the form of written test measuring students' abilities in three areas – knowledge, science processes, and application. This research was targeted at all Year 10 Science students in term two of 2002.

Year 10 Advanced Science

In 2003, the Science course at Year 10 level underwent a transformation. Outcomes based education dominated the courses. Subsequently, the structure of science at this level was re-designed. At Year 10 level, students had the option of doing one or more of the following courses – Advanced Science, Environmental Science, Experimental Science, and Core Science. Web-based lessons were designed for Advanced Science classes. Table 6.3 shows the number of students who participated in this research over two years.

Table 6.3

Statistics on the Participants in the Research.

Year	Group	Number of classes	Number of participants
2002	Year 10 Science	9	261
	Year 11 Physics	1	25
	Year 12 Physics	1	16
2003	Year 10 Advanced	2	
	Science	2	54
	Year 12 Physics		50
Total		15	406

6.5 OTHER CONSIDERATIONS

One aspect of this study involved determining if the web-based environment influenced learning outcomes. Joy and Garcia (2000) pointed out that much of the literature found no significant difference in learning effectiveness between technology-based media and conventional teaching methods. They referred to Clark's research findings (provided 15 years earlier) in which many examples of achievement gains in technology-rich environments were reported. Clark also claimed that up to 75 percent of such studies had serious design flaws (as cited in Joy & Garcia, 2000). Joy and Garcia listed a number of variables which they considered

& Garcia, 2000). Joy and Garcia listed a number of variables which they considered important in such studies, namely: attributes of the research sample, prior knowledge, ability, learner styles, teacher effects, time on task, instructional method, and media familiarity. In this research, an attempt was made to address these variables (amongst others).

6.5.1 Ability

The ability of the each student and each group was established by considering their marks in earlier school examinations.

6.5.2 Learning styles

The blended learning approach catered for a variety of learning styles. Consequently, in this instance learning style was not a significant issue.

6.5.3 Teacher effects

While most of the data collected were from the classes of one teacher (the researcher), whenever results from other classes with a different teacher were interpreted, this factor was taken into consideration.

6.5.4 Time on task

With the exception of the Year 12 class in Term 3 (2002), all students were given access to the Internet during class time for the duration of the study. These "Internet lessons" were scheduled once a week and lasted for one lesson. The duration of the Internet lesson was dictated largely by the availability of computer rooms during class time. Because of this allocation, with the exception of the Year 10 Advanced Science class (2003), all other classes had five normal classes and one lesson in the computer room. The Year 10 Advanced Science class (2003) had three normal lessons and one lesson in the computer room. The total time for science at this school was drastically reduced in 2003. The number of science lessons was reduced from six to four as a result of the school's adoption of the *Key Learning Areas* (KLA) initiatives.

During these lessons, students had the option of accessing the Internet for up to 31 minutes. The Internet lessons were designed in such a manner that students could successfully complete a lesson during the time allocated to them in the computer rooms. Students also had the option of accessing the Internet in their own time either at home or during breaks at school.

While these lessons were available to all students, those who did not have "Internet Money" were unable to individually login to the website. As explained previously, the school where the research was conducted had a user pay Internet policy where students paid 20 cents for each megabyte of information downloaded from the Internet. While the web-based lessons on *Getsmart* were designed to keep costs to a minimum (less than 20 cents per lesson in most cases), some students chose not to keep their Internet account balances "in the black". However, these students had the option of participating in the lessons by sharing a computer with a friend.

The time that students spent outside the classroom using *Getsmart* varied. While the website was able to monitor login times, it did not have the capability of recording the actual time spent by students using *Getsmart*. As in many web-based environments, time on task was not always equal to the total connection time (Bruckman, Edwards, Elliott, & Jensen, 2000). It is a factor that has been considered in interpreting the results.

6.5.5 Availability of the Internet outside lessons

Many students had an Internet connection which enabled them to access the website from home. However, for those who did not have this privilege, the computers at school were available for student use outside lesson times (before school, morning tea, lunchtime, and after school on every school day). The school had a broadband cable Internet connection. In the last year of the research, such a connection was essential to ensure that the website functioned effectively. A dial-up networking connection (which many students had in their homes) either increased the download times or made the use of the website difficult. Subsequently, this could have effected their perceptions of such environments.

6.5.6 Instructional method

The cognitive apprenticeship instructional methods embedded in *Getsmart* mimicked the variety of methods used in a traditional classroom. For instance, modelling occurs in a traditional classroom where notes, examples, and exercises are presented to students via various means such as the blackboard, handouts, overhead transparencies, dictation, etc. Similarly, exploration occurred when students visited libraries, went on excursions, and watched videos. While the instructional methods, in this study were comparable, the frequency of use of the different methods varied, which in turn had the potential of influencing learning outcomes (e.g., frequency of the use of web-based tests varied between students).

6.5.7 Media familiarity

All students in this study had completed a compulsory course on computer skills in the junior school where the use of the Internet was one of the compulsory components. If students had any difficulties utilising the Internet, then they were helped by the teachers to overcome their problems.

6.6 DATA COLLECTION METHODS

There were three key issues which had to be addressed in relation to a web-based learning environment. In such studies, researchers have the option of using either qualitative or quantitative methods. Both these methods have their strengths and weaknesses. Patton (1987, p. 9) pointed out that quantitative methods utilized standard measures that fitted diverse "opinions and experiences into predetermined response categories". These responses were "succinct, parsimonious, and easily aggregated for analysis" (Patton, 1987, p. 9). On the other hand, qualitative methods produced "a wealth of detailed data about a much smaller number of people and cases…through direct quotation" (Patton, 1987, p. 9). They were "longer, more detailed and variable in content" and analysis was difficult (Patton, 1987, p. 11).

In this study, both qualitative and quantitative methods were used because in a mixed method approach, the disadvantages of one are offset by the strengths of the other which in turn enhances the quality of the research (Jayaratne & Stewart, 1995; Tobin & Fraser, 1998). The purposes of qualitative and quantitative data on questionnaires are different, yet the information generated is complementary (Patton, 1987). Tobin and Fraser (1998) pointed out that complimentary insights could identify new problems but at same time propose possible solutions to new and persistent problems. Triangulation increases "the strength and rigor of an evaluation... by building checks and balances into a design through multiple data collection strategies" (Patton, 1987, p. 60).

Through qualitative and quantitative methods, data were collected to ascertain students' perceptions of their web-based learning environment, their attitudes, and their performance in science and physics.

6.6.1 Assessing students' perceptions

Students' perceptions of their web-based learning environment were established quantitatively by using a learning environment instrument. A modified version of the WEBLEI was used to gather data on students' perceptions of their learning environment (Appendix A). Chang and Fisher (1998) developed the WEBLEI for determining student perceptions in a university environment. The reasons underlying the choice of the instrument were discussed in Chapter 5.

The WEBLEI measures student perceptions across four scales – Access, Interaction, Response, and Results and each scale has eight items. However, the web-based learning environment in a higher-learning institution is different from that in a high school. While the former delivers programs generated by more sophisticated software (e.g., *WebCT*), the latter is based on *Getsmart,* a teacher-developed website. Hence, most of the items in the WEBLEI were either amended or changed to suit high school students. The modified version of the WEBLEI and the written survey administered to students is shown in Appendix B.

4. During computer lessons, did the website promote discussion between you and your colleagues (on the lesson that you were doing)?
5. Was the website accessible to you at all times? Give reasons.
6. Do you have access to a reliable Internet connection at all times?

In the first year of this research (2002), all students were encouraged to send emails whenever they encountered difficulties with their web-based lessons. They were also asked to send emails in which they expressed their thoughts of a web-based learning environment. These generated an in-depth look at the ways in which this new learning environment effected their learning.

6.6.2 Assessing student attitudes to science and physics

An "Attitude to Science/Physics Survey" was designed to ascertain the impact of a web-based learning environment on students' attitudes to science (or physics). This survey was administered to a selected group of students under similar conditions to the administration of the WEBLEI. This survey was administered to four out of nine classes of the Year 10 Science group in 2002. The students in these classes completed the attitude survey at the beginning and after they had completed the unit in a blended learning environment. The survey was also administered to the Year 11 Physics group in 2002 under similar conditions. The survey was re-administered to this group once they had completed their unit of work with web-based lessons in Year 12, a year later.

The attitude survey comprised of seven statements, which were formulated using some of the findings of Goodrum, Hackling, and Rennie (2001). The rationale for the formulation of these statements is explained in Chapter 9. These statements formed the Attitude to Science survey:

1. I enjoy doing physics/science.
2. Physics/Science lessons can be boring.
3. Physics/Science is one of my best subjects at school.
4. There is too much to learn in this subject.

5. I would like to do more extension work in this subject.
6. I would like to do a physics-related course at university. (For the science group the statement read - I would like to do science in Year 11.)
7. I regret enrolling in this subject.

There were two open-ended questions, which were specifically designed to ascertain the extent to which web-based learning influenced students' attitudes to their subjects. These questions were:

1. Do you think that Internet lessons made science (or physics) more interesting?
2. Would you like to have Internet lessons in science (or physics) next semester?

6.6.3 Assessing student performance in science and physics

As discussed in section 6.4, examinations at the end of each unit were in-built into the work programs. While these results were used for students' assessments, they were also useful for the purposes of measuring the impact of a web-based learning on learning outcomes. Results obtained by the sample were compared with their earlier results and also with groups who had completed similar assessments in previous years.

Students were also asked to specifically answer questions in relation to the extent to which web-based learning influenced their learning outcomes. They were asked to write answers to the following questions:

1. Do you think that *Getsmart* improved your results in Physics? Give reasons. (Or, do you think that web-based lessons last term helped you with your learning (especially with your exam results)? Please explain.
2. Do you believe that it is a good idea to supplement in class teaching with teacher-developed websites such as *Getsmart*? Give reasons.
3. What are some of the features of the website which you thought were beneficial to you as a learner? Give reasons.

4. What were your thoughts on the online tests?
5. What are some of the other features that should be incorporated in the website to improve learning outcomes?

As pointed out earlier, they also had to answer one question electronically at the conclusion of each lesson. Their responses were also recorded electronically. The question was:

How would you rate the lesson page and the test?

- Excellent
- Very Good
- Average
- Needs improvement
- A waste of time

Students' chat discussions were also analysed to establish qualitatively the extent to which such an approach to learning effected learning outcomes.

6.7 DATA ANALYSIS

In this study, all quantitative data were analysed using the *SPSS Version 11.0 for Windows* and *Microsoft Excel*. Data from the WEBLEI survey were coded and entered as 1 (*Strongly Disagree*), 2 (*Disagree*), 3 (*Neither Agree nor Disagree*), 4 (*Agree*), and 5 (*Strongly Agree*). Responses that were illegible or ignored were eliminated pair wise from the survey. Statistical measurements such as mean, median, standard deviation, Alpha Reliability, and Discriminant Validity were determined using the *Statistical Package for the Social Sciences* (SPSS) software. Graphs were drawn using *Microsoft Excel.*

All emails and answers to written questions were read and the key points were identified in each instance. For analysis purposes, this information was then recorded on a *Microsoft Access* database. The qualitative data was then analysed by grouping the responses into categories which reflected the student responses. Web-based chat discussions were interpreted individually.

6.8 CHAPTER SUMMARY

The aim of this research was to study the impact of web-based learning (in a blended environment) on student perceptions, attitudes, and performance. The researcher (high school maths-science teacher with no formal training in ICT) developed *Getsmart* that was based on the instructional methods of cognitive apprenticeship.

Students had access to the website in school time and outside school. The variables that had the potential to impact on the outcomes of this research were identified. A modified version of the WEBLEI and an attitude survey were used to collect data. Data were also collected electronically via the website. Students also completed a written survey. Emails sent by students and web-based chat provided additional forms of qualitative data. Data analysis was performed by using three commercially available software packages.

The next section comprises of five chapters in which the results of this study are presented and discussed.

CHAPTER 7

STUDENTS' PERCEPTIONS OF A WEB-BASED LEARNING ENVIRONMENT BASED ON QUANTITATIVE FINDINGS

7.1 INTRODUCTION

For any innovation to succeed as an instructional tool in education, learners have to respond positively to it. Creating a learning environment which provokes positive perceptions amongst learners is an important variable because it can generate desirable learning outcomes. The Lewinian formula, B = f(P, E) proposed that human behaviour (B) was a function of the personal characteristics of an individual (P) and his or her environment (E) (Fraser, 1998a). Other researchers have also highlighted the importance of the environment in human development.

> Today, consensus tells us that heredity provides 30 to 60 percent of our brains wiring, and 40 to 70 percent is the environmental impact...as educators, we can most influence the "nurture" aspects of students...we must follow a cardinal rule when it comes to appreciating how the brain reacts to certain influences: Start by removing threats from the learning environment...eliminate the negatives.
>
> (Jensen, 1998, p. 30)

Jensen (1998) highlighted the importance of the learning environment and the need to eliminate the negatives in order to ensure healthy development of the "brain's wiring" amongst learners. The overall picture of science in Australian schools and elsewhere is not a healthy one and this has been discussed in depth in Chapter 4. Goodrum, Hackling, and Rennie's (2001) report highlighted an aura of dissatisfaction which existed amongst science students. The interest in science needs to be reinvigorated and this can be achieved by eliminating the negatives from the learning environment. According to Lowe (*Science Initial in-service materials*, 1999), traditional teaching methods based on the "Moses" model have served their purpose. Replacing these methods overnight may not be a viable option, therefore, renovating them may be a more feasible alternative. The renovated model should also be free of any gender bias. It is only through innovative initiatives that issues such as diminishing interest in science can be addressed.

New initiatives will entail innovative teaching methods and the extent to which they are successful will have to be studied. In this research, a web-based teaching approach was used in a blended learning environment for students in junior science and senior physics classes at a high school. The importance of positive students' perceptions toward their learning environments has been emphasised in previous paragraphs. Hence, in this study, ascertaining students' perceptions of a blended web-based learning environment was very important.

Students' perceptions of this learning environment were studied extensively through qualitative and quantitative methods. In this chapter, the quantitative findings of a modified version of the WEBLEI are discussed. As discussed in Chapter Five, the WEBLEI (Chang & Fisher, 1998) is probably the only learning environment instrument which can effectively establish student perceptions of such a learning environment.

This study involved 406 students from 15 classes of three subjects (physics, science, and advanced science) who were immersed in a blended learning environment of normal and online lessons. Lessons were uploaded to *Getsmart,* a website specifically designed for this purpose. Each group had exposure to the blended learning approach for a school term. *Getsmart* evolved as the research progressed. This was necessary for two reasons namely, there were improvements in technology; and the feedback from users was incorporated in the design to make it more learner-friendly.

Students were administered the WEBLEI at the completion of their work and assessments at the end of the term. All classes completed the survey in which they responded to the items as it related to their *actual* environment. In addition to this, students in two classes responded to the WEBLEI as it related to their *preferred* environment. The study was conducted over two years which also coincided with improvements to the website.

The reliability and validity of the WEBLEI has been established in an online tertiary environment, but no such study had been done in high schools (Chang & Fisher, 2003). In section 7.2, the reliability and validity data of the modified instrument are presented. The website had various features for students in 2002. More features were added to the website in 2003. Consequently, the perceptions of the students over the years could have been influenced by variations in the website. For this reason, the WEBLEI results obtained in 2002 and 2003 are presented separately in sections 7.3 and 7.4 respectively. Section 7.5 of this chapter presents an overview of students' perceptions of a blended web-based learning environment that was generated by the WEBLEI. The last section (7.6) presents a chapter summary.

7.2 RELIABILITY AND VALIDITY OF THE WEBLEI

The reliability analysis gives an idea of the extent to which items in the same scale are related to each other. The Cronbach alpha reliability coefficient measures the internal consistency and is based on the average inter-item correlation. All values above 0.60 obtained through this calculation are considered to be acceptable (Nunnally, 1967).

Table 7.1

Alpha Reliability Coefficient for the Actual and Preferred forms of the WEBLEI.

WEBLEI Scales	Alpha Reliability		Valid Cases	
	Actual	Preferred	Actual	Preferred
Access	0.82	0.96	291	26
Interaction	0.78	0.90	289	26
Response	0.86	0.87	290	26
Results	0.86	0.96	291	26

In this study, the alpha reliability coefficient for the actual environment survey ranged from 0.78 to 0.86 (Table 7.1). For the preferred environment survey, the value of alpha reliability coefficients ranged from 0.87 to 0.96. In this case, the values of the alpha reliability coefficients were higher than those reported by Chang and Fisher (2003). In Chang and Fisher's study, the WEBLEI was administered to off-campus, tertiary students. For the purposes of this research, the WEBLEI was a reliable instrument.

Table 7.2

Discriminant Validity and ANOVA measurement for the Actual and Preferred forms of the WEBLEI.

WEBLEI Scales	Discriminant Validity Actual	Discriminant Validity Preferred	Valid Cases Actual	Valid Cases Preferred	ANOVA# Eta^2
Access	0.52	0.96	282	26	0.08
Interaction	0.58	0.86	273	26	0.17^{**}
Response	0.58	0.86	273	26	0.09^{*}
Results	0.59	0.96	273	26	0.13^{**}

Based on actual forms which consisted of students in 15 classes
$^*p<0.05$. $^{**}p<0.01$.

The discriminant validity (Table 7.2) identifies the extent to which a scale measures a unique dimension not covered by other scales in the instrument. In this study, the discriminant validity obtained ranged from 0.52 to 0.59 for the actual form. In the study by Chang and Fisher (1998) the discriminant validity ranged from 0.37 to 0.49 which suggests that in both studies, the WEBLEI measured distinct, yet some overlapping aspects of the actual learning environment. However, this was not the case with the preferred environment. The discriminant validities ranged from 0.86 to 0.96 (as shown in the table above) which suggested that the scales measured similar aspects of the learning environment.

An ANOVA compares the means for different groups. *Eta* squared is the proportion of variance in the dependent variable that is explained by the independent variable. It is also an indication of how well an instrument is able to measure the difference between classes (Nair & Fisher, 1999). In this instance, the difference between the means of the classes was significant for the Interaction ($p<0.01$), Response ($p<0.05$), and Results ($p < 0.01$) scales.

7.3 PERCEPTIONS OF THE SAMPLE IN 2002

In 2002, the website had five features namely: lesson pages with graphics, multiple choice tests, email option, and links to other sites. Students in physics classes had access to an online chat facility. In this section, the perceptions of the whole group are initially discussed (7.3.1). The results are then presented in terms of how different variables influenced students' perceptions across the four scales. These variables focussed on the effect of teachers, subjects, and gender on students' perceptions. These are discussed in sections 7.3.2, 7.3.3, and 7.3.4 respectively.

7.3.1 Perceptions of the whole group

More than 70% of all students who participated in the blended learning approach submitted their WEBLEI questionnaires. These questionnaires measured their perceptions of the actual environment. A five-point Likert response format was used in this survey for each item in the four scales. The responses were scored as follows – *Strongly Agree* (5), *Agree* (4), *Neither Agree nor Disagree* (3), *Disagree* (2), *and Strongly Disagree* (1). Item 24 was the only one which was worded in reverse and scored accordingly.

The mean and the standard deviation for each scale of the WEBLEI are presented in Table 7.3. The mean for each scale was very close to four for all scales (except for the Interaction scale where it was 3.53).

Table 7.3

Mean and Standard Deviations for the Four scales of the Actual form of the WEBLEI in 2002.

WEBLEI Scales	Descriptive Statistics		
	Mean	Standard Deviation	Valid Cases
Access	3.99	0.61	208
Interaction	3.58	0.71	206
Response	3.80	0.68	209
Results	3.94	0.60	206

For the Response and Results scales (Table 7.3), the means were slightly higher than those reported by Chang and Fisher (2003). They reported means of 3.96 for the Access scale, 3.55 for the Interaction scale, 3.37 for the Response scale and 3.72 for Results scale. In this research, means of 3.99, 3.58, 3.80, and 3.94 were obtained for the Access, Interaction, Response, and Results scales respectively.

The figures in Table 7.3 suggest that students in high schools have slightly more positive perceptions of a web-based learning environment than students in a tertiary setting. Using the College and University Classroom Environment Inventory (CUCEI), Nair and Fisher (2001) reported that secondary school students had more positive perceptions of their learning environments than students in tertiary environments. It must be realised though that the study by Chang and Fisher (2003) was based on tertiary students who had participated wholly in an online learning environment. The standard deviation for each scale was marginally higher than those reported by Chang and Fisher (2003). A higher standard deviation suggests that there was greater variation in students' responses in a high school environment than at a tertiary level. The means obtained by Chang and Fisher (2003) and those calculated in the 2002 sample are plotted in Figure 7.1.

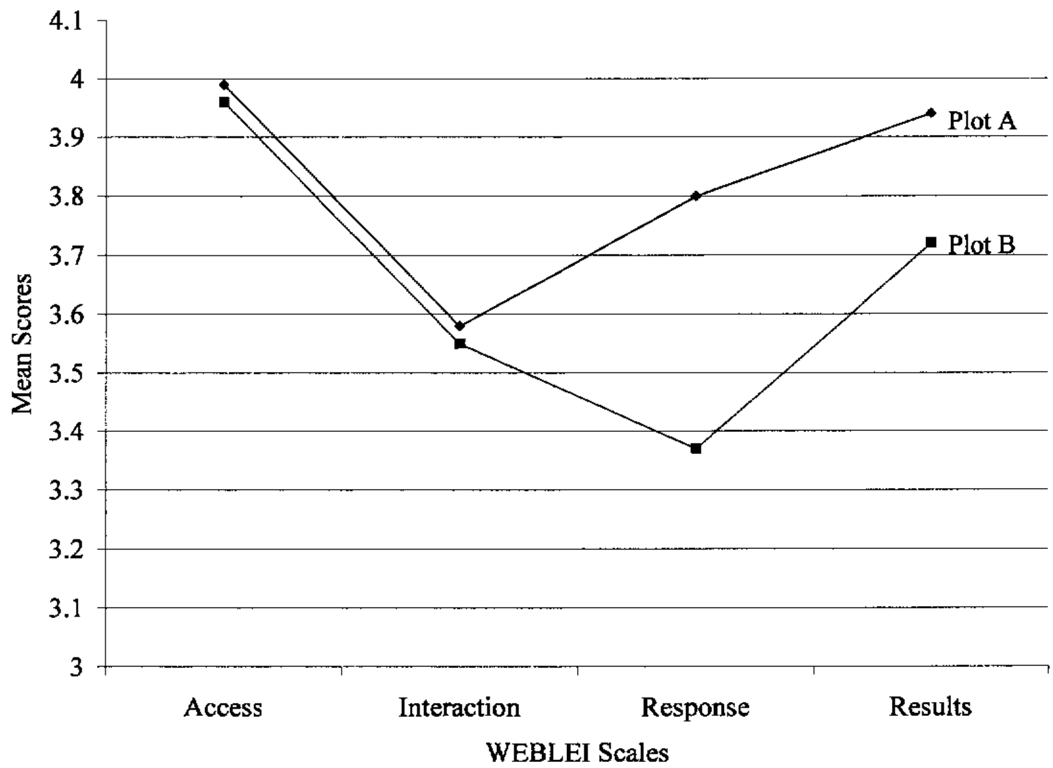


Figure 7.1. Profiles of Mean WEBLEI Scores for the 2002 sample (Plot A) and the means reported by Chang and Fisher (2003) (Plot B).

A mean of 3.99 (*SD* = 0.61) (Table 7.3) for the Access scale suggests that students agreed that their learning environment was easily accessible at locations suitable to them. It was also convenient and it enabled them to work at their own pace. A web-based environment also gave them greater autonomy in achieving their learning objectives.

The Interaction scale produced a mean of 3.58 (*SD* = 0.71), the lowest of all three scales. An average of three implied that students neither agreed nor disagreed with all the items in the scale. A mean of four suggested that they agreed with the statements. A mean of 3.58 suggests that there was agreement to a certain degree to the items of the Interaction scale.

The items associated with the Interaction scale are reproduced below. The means and standard deviation of the sample for each item is shown in brackets.

9. I communicate with my teacher in this subject electronically via email. (M = 3.41, SD = 1.29)
10. In this learning environment, I have to be self-disciplined in order to learn. (M = 3.40, SD = 1.20)
11. I have the option to ask my teacher what I do not understand by sending an email. (M = 3.61, SD = 1.27)
12. I feel comfortable asking my teacher questions via an email. (M = 3.31, SD = 1.34)
13. The teacher responds to my emails. (M = 3.10, SD = 1.23)
14. I can ask other students what I do not understand during computer lessons. (M = 3.98, SD = 1.08)
15. Other students respond positively to questions in relation to Internet lessons. (M = 3.76, SD = 0.93)
16. I was encouraged by the positive attitude of my friends towards the Internet lessons. (M = 3.55, SD = 0.98)

From the means above, it is obvious that the items generally in relation to emails have been the ones in which the students expressed the greatest uncertainty ($M \approx 3$). As stated previously, a mean of approximately three suggests that students neither agreed nor disagreed with the items. One hundred and seventy one emails were received and responded to by the researcher, which suggested that almost one in two students communicated in this manner. In section 7.5, this issue is explored further to identify the possible reasons for these responses.

A mean score of 3.80 (SD = 0.68) was obtained for the Response scale (Table 7.3) which implied that students generally agreed web-based learning was satisfying and it enabled them to interact with other students and their teachers. They also enjoyed learning in this environment and they believed that this approach held their interest in the subject for the whole term.

The lowest scoring item for the Response scale was item 24 ("I felt a sense of boredom in this subject towards end of this term.") with a mean of 3.24 (SD = 1.26).

The standard deviation was also comparatively larger which suggests that there was some variation in students' responses. Numerous studies (eg. Goodrum, Hackling, & Rennie, 2001) have shown that students were bored in science lessons. It was interesting that for item 24, the class means ranged from 2.33 to 3.90 which indicated that student responses ranged from agreeing to disagreeing with the item. As pointed out by some researchers (eg. Eklund, Kay, & Lynch, 2003; Newhouse, 2000), technology alone did not enhance student interest towards lessons. The ability and the enthusiasm of teachers to integrate technologies into the teaching context was an essential element in the success of the online teaching approach.

The WEBLEI was designed with a unique rationale. When Chang and Fisher (1998) developed the WEBLEI, they pointed out that scales one to four were related to each other in an ascending order. The responses to the items in the Results scale depended to a large extent on how students related to the items in scales one to three. Hence, the Results scale was probably the most significant because it reflected students' perceptions of what they had gained through the web-based learning experience. The rationale of the design of the WEBLEI also suggested that if students did not have positive perceptions of the Access, Interaction, and Response scales, then this was most likely to effect the Results scale.

In the Results scale, individual items had means that ranged from 3.62 to 4.12. It was interesting to note that items 25, 26, 30, 31, and 32 had means greater than 3.80.

25. I can work out exactly what each lesson on the Internet is about. ($M = 3.88$, $SD = 0.92$)
26. The organisation of each lesson on the Internet is easy to follow. ($M = 4.13$, $SD = 0.83$)
30. The subject content is appropriate for delivery on the Internet. ($M = 3.90$, $SD = 0.91$)
31. The presentation of the subject content is clear. ($M = 4.01$, $SD = 0.84$)
32. The multiple choice test at the end of each lesson on the Internet improves my learning in this subject. ($M = 4.01$, $SD = 1.04$)

For the Results scale, Chang and Fisher (1998) reported a mean of 3.75. In this research, the mean score of 3.94 (*SD* = 0.60) showed that students agreed they could establish the purpose of web-based lessons. It was also easy to follow, well sequenced, and clear. The structure kept them focussed and it helped them learn better the work that was done in class. The content was presented well and it was appropriate for delivery in a web-based learning environment. The tests at the end of the lessons, improved their understanding in the subject.

The data analysed for the whole group revealed that students were satisfied with the desired characteristics of the Access, Response, and Results scales. They agreed to a certain extent with the desired characteristics of the Interaction scale. The mean for the Interaction scale (*M* = 3.53) was slightly lower in comparison with the others (*M* = 3.96, *M* = 3.80, *M* = 3.91 for Access, Response and Results scales respectively). If the rationale of the WEBLEI is assumed to be correct then the deficiency associated with this Interaction scale must have been fulfilled through other channels; otherwise the mean for the Results scale would not have been as high. It should also be borne in mind that in a blended learning approach, there are additional interaction opportunities other than the Internet. The possible reasons for the variation in the means of these scales are explored in the sections that follow.

7.3.2 Perceptions of the learning environment – the teacher factor

In many instances, when innovations fail, teachers are often blamed. A more significant problem is that teaching online courses is a complex and challenging task (Anderson, Rourke, Garrison, & Archer, 2001). Additionally, issues relating to technical aspects of delivering quality educational materials and training students to foster knowledge acquisition within this new environment can be a complicated process (Gold, 2001). Teachers who used *Getsmart* could not be given any specialized training. In state schools, financial resources and time are important constraints in teacher training. Hence, in the design of *Getsmart,* user friendliness was an important priority to ensure that all users (including teachers) adapted to the technology with ease.

As mentioned earlier in this chapter, there was some evidence that the role of a teacher was far more important than the instructional design of the content (Eklund, Kay, & Lynch, 2003). While it is difficult to measure the impact of teachers on student perceptions in such an environment, the difference between students' perceptions in different classes can be successfully determined. In this study, the researcher was one of the teachers whose classes used *Getsmart* in a blended learning environment. He had four classes (two junior science and two physics classes) out of the 11 classes that participated in this study in 2002. Table 7.4 lists the means for each scale obtained in his classes and the combined mean of the rest of the group.

Table 7.4

Mean and Standard Deviations for the Four Scales of the WEBLEI (Actual) in 2002 in the Researcher's Classes' and the Other Classes.

WEBLEI Scales	Descriptive Statistics						
	Mean			Standard Deviation		Valid Cases	
	Researcher's Classes# (1)	All other classes## (2)	Difference in means (1) – (2)	Researcher's Classes	All other classes	Researcher's Classes	All other classes
Access	3.99	3.98	0.01	0.61	0.61	78	130
Interaction	3.79	3.44	0.35**	0.62	0.74	79	127
Response	3.90	3.74	0.16	0.63	0.70	77	132
Results	4.05	3.88	0.17*	0.55	0.61	77	129

Researcher taught 4 classes
The remaining 7 classes were taught by 6 teachers
*$p < 0.05$. **$p < 0.01$.

The independent-samples t-test procedure compares the means for two groups. This test was used throughout this study for comparing the means obtained from two independent samples. The normality of the data was established through boxplots and normal and detrended *Q-Q plots*. Levene's Test of equality of variances was also performed. If the significance value for this test was high ($p > 0.05$) then calculated values which assumed equal variances for both groups were used in the discussions which followed.

In this case there was a significant effect for the Interaction ($t(187) = 3.66$, $p<0.01$) and the Results ($t(204) = 2.13$, $p<0.05$) scales, with students in the researcher's classes scoring higher means than students in other classes. These results show that the role of teachers in such an environment may be an important issue. Additionally, how teachers market and apply appropriate teaching pedagogies in such an environment may be crucial in influencing students' perceptions. While all classes (except the Year 12 Physics class) had the same amount of time on the Internet (in school time), the manner in which the online activities were integrated into the traditional classes depended on the teacher. The degree of enthusiasm and commitment of the teacher to an alternative teaching approach could also be an aspect which influenced student perceptions. Another important issue is that learning styles and motivation of students could vary between classes. While all classes were meant to be theoretically homogeneous, sometimes the mix of students can also be a mitigating factor in terms of how students' perceived their learning environments.

This factor is further explored in the four classes that were taught by the researcher (Table 7.5). Online lessons were integrated in the same manner in three of the four classes. The Year 12 Physics could not obtain access to computers during class time. They had to access the website in their own time either at school or at home. Significantly, they had an online "chat" tutorial (discussed in detail in the next chapter) after school for an hour, each week for a term.

Table 7.5

Mean and Standard Deviations for the Four Scales of the Actual Form of the WEBLEI in the Researcher's Classes (2002).

WEBLEI Scales	Descriptive Statistics							
	Mean				Standard Deviation			
	10.4 science	10.5 science	11.1 physics	12.1 physics	10.4 science	10.5 science	11.1 physics	12.1 physics
Access	3.98	3.74	4.16	4.22	0.72	0.63	0.41	0.49
Interaction	3.92	3.43	4.05	3.76	0.71	0.55	0.34	0.63
Response	4.10	3.70	3.93	3.81	0.73	0.70	0.40	0.56
Results	4.08	3.87	4.26	3.99	0.71	0.58	0.34	0.18
Valid Cases	25	23	21	10	25	23	21	10

It was interesting to note that one of the classes (Year 10.5 science class) scored the lowest mean on all four scales (Table 7.5). The mean ranged from 3.43 to 3.87 for the Year 10.5 science class, which suggested that they agreed to some of the items of each scale. However, the degree of agreement in this class was the least when compared with the other classes. The standard deviations of the Year 11 Physics class (*SD* = 0.41, *SD* = 0.34, *SD* = 0.40, *SD* = 0.34 for the Access, Interaction, Response and Results scales respectively) were significantly lower than other classes which perhaps indicated that there was least variation in terms of how students scored the items in this class. On the whole, the standard deviations for each scale for physics students was lower than the science students, showing that there was a greater uniformity in terms of how physics students perceived their learning environments than those in junior Science. The variation between class means also shows that even though students may have the same teacher and they are all taught the same way, there is probably a limit to how much a teacher can influence students' perceptions of the learning environment. As Jensen (1998) pointed out, 30 to 60 percent of our learning was due to our brain's wiring, and 40 to 70 percent is a result of the environmental impact. Hence, for the 10.5 science class that had the lowest means across all four scales (see Table 7.5), other factors may have dictated student perceptions.

7.3.3 Perceptions of the learning environment – the subject factor

Nine junior science (year 10) and two senior physics (year 11 and year 12) classes participated in this study in 2002. While the year 10 classes were comprised of students who may or may not have wanted to study science (science was compulsory to the end of year 10 in 2002), the students in senior physics classes chose physics. For this reason, it could be assumed that a larger proportion of students in senior physics were more inclined to like and have positive attitudes towards the subject than those in junior classes. Consequently, they were more likely to feel more positive about an innovative learning environment that was likely to improve their results.

Table 7.6

Mean and Standard Deviations for the Four Scales of the Actual Form of the WEBLEI in Junior Science and Senior Physics.

WEBLEI Scales	Descriptive Statistics						
	Mean			Standard Deviation		Valid Cases	
	Junior science (1)	Senior physics (2)	Difference in means (1) – (2)	Junior science	Senior physics	Junior science	Senior physics
Access	3.95	4.18	-0.23*	0.63	0.43	177	31
Interaction	3.51	3.96	-0.45**	0.73	0.47	175	31
Response	3.79	3.89	-0.10	0.71	0.45	178	31
Results	3.90	4.17	-0.27*	0.63	0.32	175	31

*$p<0.05$. **$p<0.01$.

As shown in Table 7.6, all the means were higher for students in senior physics than students in junior science. These differences were significant for the Access ($t(55) = -2.57, p<0.01$), Interaction ($t(60) = -4.47, p<0.01$) and the Results ($t(78) = -3.58, p< 0.05$) scales. As pointed out earlier, the difference in these means is largely because physics students are probably more motivated than students are in junior science classes. Consequently, they perceive their learning environments more positively than did those in junior science. Waxman and Huang (1998) for instance also reported that students in the middle school perceived their learning environments less favourably than those in elementary or high schools.

7.3.4 Perceptions of the learning environment – the gender factor

Studies to date (e.g., Hofstein, Kesner, & Ben-Zvi, 1999; Majeed, Fraser, & Aldridge, 2002; McInerney & McInerney, 2002; Waxman & Huang, 1998) revealed that there could be a difference in the perceptions of boys and girls towards technology or none at all. Nonetheless, as Creemers and Reezigt (1999) pointed out, research findings could vary from one situation to the next. Hence, the impact of a web-based learning environment on gender is yet to be fully understood. Perhaps the situation and the type of the learning experience influenced perceptions.

Sherman, End, Kraan, Cole, Campbell, Birchmeier, and Cohara (1999, p. 4) reported that in a technology rich environment, men and woman were "becoming more similar in self-perceptions" but a gap existed in their "attitudes about their experience with computer technology with the college curriculum." They also pointed out that "understanding how college men and woman approach the pedagogical use of Internet technology may increase its effectiveness" (Sherman et al., 1999, p.1). Any educational innovation should be a fair learning environment for both sexes. The impact of a web-based learning was investigated in this study to assess its fairness in this respect.

Table 7.7

Mean and Standard Deviations of Boys and Girls for the Four Scales of the Actual Form of the WEBLEI.

WEBLEI Scales	Descriptive Statistics						
	Mean			Standard Deviation		Number of Cases	
	Boys (1)	Girls (2)	Difference in means (1)-(2)	Boys	Girls	Boys	Girls
Access	4.04	3.92	0.12	0.65	0.55	118	90
Interaction	3.65	3.49	0.16	0.70	0.72	114	92
Response	3.86	3.72	0.14	0.68	0.68	118	91
Results	3.98	3.89	0.09	0.61	0.59	116	90

The results above are interesting because both boys and girls perceived the learning environment similarly. While the boys have scored higher means for each scale, the difference between the two sexes was not significant ($p<0.05$). A finding such as this is significant in the "swinging pendulum debate" where one sex is perceived to be favoured more than the other in classrooms. Such a perception exists not only amongst the public, but also amongst some academics. Palmer, an academic at an Australian university was quoted in the *NT News* as having said that the curriculum "used to be made for boys, but there are now a greater number of female teachers and this has led to discipline, curriculum, going ... more towards girls" (Bevin, 2002, p. 9). In this instance, the web-based learning environment appears to be a learning medium which is preferred equally by both sexes. Creating such fair environments must be pleasing to education authorities because it has the potential to create equal opportunities for all.

In this sample, the ratio of boys to girls in junior science was almost one to one, while, in senior physics there were fewer students and the ratio of boys to girls was almost three to one. Such ratios have existed in physics classrooms for more than twenty years (McKittrick, Mulhall, & Gunstone, 1999). A further analysis of the data on the basis of sex and subjects was also carried out to see if there was a difference between boys and girls in junior science and senior physics. These results are presented in Table 7.8.

Table 7.8

Mean and Standard Deviations for the Four Scales of the Actual Form of the WEBLEI for Boys and Girls in Junior Science and in Physics.

WEBLEI Scales	Descriptive Statistics						
	Mean			Standard Deviation		Number of cases	
	Boys (1)	Girls (2)	Difference in means (1)-(2)	Boys	Girls	Boys	Girls
			Junior science				
Access	3.99	3.90	0.09	0.69	0.55	96	81
Interaction	3.58	3.42	0.16	0.73	0.72	92	83
Response	3.83	3.74	0.09	0.72	0.70	96	82
Results	3.95	3.85	0.06	0.65	0.59	94	81
			Senior physics				
Access	4.24	4.06	0.18	0.39	0.52	22	9
Interaction	3.93	4.04	-0.11	0.47	0.48	22	7
Response	4.00	3.63	0.37*	0.37	0.54	22	9
Results	4.13	4.26	-0.13	0.31	0.34	22	9

* $p<0.05$

In the data above (Table 7.8) while the boys achieved higher means in junior science than girls for each scale, the difference between the means was not statistically significant ($p<0.05$). In senior physics, the boys scored higher on the Access and Response scales, whereas the girls scored higher on the Interaction and Results scales. Even though there were differences between the means, these differences were only significant for the Response scale ($t(29) = 2.23, p<0.05$). The higher mean for boys in this scale makes the researcher conclude that boys in physics classes were more satisfied with such an approach than girls. Another analysis was carried out to see if a difference existed between girls in junior science and physics. A similar analysis was conducted for the boys. These results follow in Table 7.9.

Table 7.9

Mean and Standard Deviations for the Four Scales of the Actual Form of the WEBLEI for Boys in Junior Science and in Physics and Girls in Junior Science and in Physics.

WEBLEI Scales	Descriptive Statistics						
	Mean			Standard Deviation		Number of Cases	
	Junior science (1)	Physics (2)	Difference in means (1)-(2)	Junior science	Physics	Junior science	Physics
			Boys				
Access	3.99	4.24	-0.25	0.69	0.39	96	22
Interaction	3.58	3.93	-0.35*	0.73	0.47	92	22
Response	3.83	4.00	- 0.17	0.72	0.37	96	22
Results	3.95	4.13	-0.18	0.65	0.31	94	22
			Girls				
Access	3.90	4.06	-0.16	0.55	0.52	81	9
Interaction	3.42	4.04	-0.62*	0.72	0.48	83	7
Response	3.74	3.63	0.11	0.70	0.54	82	9
Results	3.85	4.26	-0.41*	0.59	0.34	81	9

*$p< 0.05$.

The results in the table above show that the perceptions of a web-based learning environment of both girls and boys in junior science were lower than boys and girls in senior physics for all four scales. There was a significant result on the Interaction scale, ($t(49)$ = - 2.70, p<0.05) with boys in junior science achieving lower mean scores than boys in senior physics classes. Similarly, girls in junior science had lower means than girls in senior physics for all scales except the Response scale. This difference was statistically significant for the Interaction ($t(90)$ = - 2.51, p<0.05) and the Results ($t(88)$ = -2.10, p<0.05) scales. Students in physics had an opportunity to participate in online chat sessions which was probably one of the additional factors explaining their more positive perceptions across all four scales.

For reasons explained previously, they were probably more motivated to utilise online resources to their advantage.

The results presented so far on the gender factor suggest that on the whole there is no difference between boys and girls in terms of their perceptions of a web-based learning environment, but boys and girls in physics generally had more positive perceptions because they were more motivated, chose it because they wanted to do and were probably more mature than their Year 10 counterparts. Hence, they were more likely to seize educational opportunities that had the potential to enhance their learning outcomes.

The results obtained in 2002 suggested that students had positive perceptions of their web-based learning environment. While students in senior physics had more positive perceptions than those in junior science classes, there was no significant difference between the perceptions of boys and girls.

7.4 PERCEPTIONS OF THE SAMPLE IN 2003

The study was continued in 2003 and other aspects of the research were explored. Continued research also gave an opportunity to reflect on the results obtained in the previous year. As technology and the researcher's technological abilities improved and learner feedback was incorporated, the capability and design features of *Getsmart* also improved. *Getsmart* had the following features in 2003:

- Lesson pages with improved graphics
- Revision page(s) per unit or topic
- Key words list per page
- Some lessons had downloadable worksheets
- *Html* pages replaced by pages written in *asp*
- Multiple choice and short answers tests
- Email option
- Links to other sites
- Own domain name (u2cangetsmart.com)
- Online simulations, movies and experiments

- Password login
- User feedback capability
- Tracking login frequency and test results via a database

There were four classes in two subject areas that participated in this study in 2003. The findings in senior physics (7.4.1) and science (7.4.2) are reported. Results of students' perceptions of their preferred and actual environments are also presented (7.4.3).

7.4.1 Perceptions of the learning environment of students in senior physics

There were two physics classes; one of these classes participated in the study in 2002 (12A Phy.). The other group (12B Phy. with a different teacher) was also given the option to participate in 2002 but chose not to do so. It appeared that there was reluctance on the part of the students to participate in the blended approach to teaching and learning. In 2003, attitudes of students towards this approach in the 12B physics class changed and both classes were allocated one lesson per week (the same as in the previous year) to access *Getsmart.* While classes were allocated this time, it was up to the teachers to decide how online learning would be blended in with their traditional teaching (same as in the previous year). All students in 12B physics could not access the computers at the same time; hence the class was split into two groups. Each group however, had the same time as students in the other group.

The WEBLEI scores of the two physics were compared. The second class participated in web-based learning for the first time (as explained above). The means in each scale for these classes were compared (Table 7.10).

Table 7.10

Descriptive Statistics of the WEBLEI Scales based on Year 12 Physics Results in 2003.

WEBLEI Scales	Descriptive Statistics						
	Mean			Standard Deviation		Valid Cases	
	12A# Phy. (1)	12B Phy. (2)	Difference Between means (1) – (2)	12A# Phy.	12B Phy.	12A# Phy.	12B Phy.
Access	4.04	4.16	- 0.13	0.40	0.47	16	14
Interaction	3.48	3.38	0.10	0.38	0.53	16	14
Response	3.59	3.58	0.01	0.44	0.65	16	14
Results	4.04	4.02	0.02	0.24	0.58	16	14

Class taught by the researcher. This class had experienced web-based learning in 2002.

As revealed in Table 7.10, in both physics classes, the perceptions of students' of their online learning environment was comparable. The difference in the means across all four scales was not statistically significant ($p<0.05$). In this instance, it was not the difference in the means, but rather their closeness that was interesting. This was due to two reasons. Firstly, one of the classes was involved in web-based learning for the second time. Secondly, both classes had different teachers. Despite these variables, the means were almost similar. It was noteworthy that the standard deviations for all scales were consistently smaller in one class than the other. The low standard deviation suggests that students' responses were closer to each other in one of the classes (12A Phy – the class which was involved in the web-based learning approach for the second time) than the other (12B Phy). When the combined responses of these two classes were compared with the WEBLEI means of the Year 12 class in 2002, there were some differences, but these differences were not statistically significant ($p<0.05$) (Table 7.11).

Table 7.11

Descriptive Statistics of the WEBLEI Scales based on Year 12 Physics Classes that Participated in Web-based Learning in 2002 and 2003.

WEBLEI Scales	Descriptive Statistics						
	Mean			Standard Deviation		Valid Cases	
	PHY 2003 (1)	PHY 2002 (2)	Difference Between means (1) – (2)	PHY 2003 (1)	PHY 2002 (2)	PHY 2003 (1)	PHY 2002 (2)
Access	4.10	4.24	- 0.14	0.43	0.49	30	10
Interaction	3.44	3.76	- 0.32	0.45	0.63	30	10
Response	3.58	3.81	- 0.23	0.54	0.56	30	10
Results	4.03	3.99	0.04	0.43	0.18	30	10

The means of the first three scales were lower in 2003 when compared with 2002. The mean for the Results scale was marginally higher, though in 2003, the website underwent a facelift. Contrary to the researcher's beliefs, instead of increasing, the means declined in three of the scales. Such a decline (even though it was not significant) perhaps suggests that students did not perceive improvements to technology in the same manner as the teachers did. Another factor was the timing of web-based learning in year 12. For some students', term three is very busy because there are many assessment items to complete in all subjects. For other students, it is just another term which they have to finish before they complete high school. By this stage the enthusiasm and energies they had in year 11 is either drained or channelled to other subjects in which they believed they could improve. The researcher's observations suggested that the students in Year 12 Physics in 2002 were more focussed and more at ease with technology than those in 2003. Hence, the mix of students can influence perceptions.

Many studies on learning environments have investigated the characteristics of the actual classroom environments. Very few investigations have explored the impact of interventions on these environments (Fraser, 1994; McRobbie & Thomas, 2000). In this study, the perceptions of the students in the Year 11 Physics class in 2002 (that subsequently became the 12A PHY class in 2003) was monitored through the

WEBLEI and qualitative methods. The WEBLEI results obtained over two years are listed in Table 7.12.

Table 7.12

Descriptive Statistics of the WEBLEI Scales based on the Physics Class that Participated in Web-based Learning in 2002 and 2003 (In both years, this class had the same teacher).

WEBLEI Scales	Descriptive Statistics						
	Mean			Standard Deviation		Valid Cases	
	2002 (1)	2003 (2)	Difference (1) – (2)	2002	2003	2002	2003
Access	4.23	4.19	0.04	0.43	0.39	15	16
Interaction	4.09	3.61	0.48**	0.40	0.44	15	16
Response	3.96	3.73	0.23	0.39	0.43	15	16
Results	4.27	4.15	0.12	0.36	0.31	15	16

**$p<0.05$.

Despite improvements to the website in 2003 (Table 7.12), it appears student perceptions in three of the four scales remained almost unchanged. Some of the reasons for this observation were intimated on the previous page. Here for the Interaction scale means differ, $t(29) = 3.16$, $p<0.05$, with the students scoring a higher mean in 2002 than in 2003.

The Interaction scale gives an indication of the extent to which the web-based learning environment facilitates interaction between participants. One significant change from the previous year was the absence of the chat and *Forum* options from the website. There were a few reasons which led to this change. Firstly, though the chat and *Forum* options were available in 2002, very few students in this physics class participated actively. For these activities to be beneficial there is a need for two-way communication. Secondly, managing a chat lesson and the *Forum* discussion board required a significant input in terms of the researcher's time after school. In 2003, the researcher did not have enough time to participate in online chats (or *Forum* discussion boards) so these options were not feasible. (Even though students found synchronous online interactions educationally productive, teachers have to put in additional time voluntarily to enable this feature to work.). A closer examination of the student responses over two years showed a decline in the means of only two items in the Interaction scale in 2003 that were significant. The items were:

9. I communicate with my teacher in this subject electronically via email. ($t(29) = -4.93, p<0.01$)

15. Other students respond positively to questions in relation to Internet lessons. ($t(29) = -2.70, p<0.05$)

The means for Item 12, which is related to Item 9, were also revealing. The mean for this item ("I feel comfortable asking my teacher questions via an email") decreased from 4.13 ($SD = 0.92$) in 2002 to 3.69 ($SD = 0.70$) in 2003. Even though this change was not statistically significant ($p<0.05$), it does make it seem that in 2002 there was a higher proportion of students who felt comfortable asking questions via email than in 2003. While it would be assumed that as students matured, their willingness to participate in discussions on a one-to-one basis with their teachers would be more spontaneous, this was not the case with this group. Perhaps they did not have satisfactory responses to their emails from their teacher the previous year. While the teacher (researcher in this case) responded to all emails, the emails did not lead to any further discussions. Many emails were expressions of what students thought of an online learning environment. Each reply to the respondents was positively stated and they were thanked for their comments.

In many cases, teachers assume that students know how to ask questions via email. Is this a valid assumption? How many students know what they do not know about a concept and express it in writing? The reason for this perception was explored further through qualitative surveys and is revisited later in this chapter (7.2.5) and in the next chapter. If students do not feel comfortable asking questions via email, then they will not send emails, which explained the decline in the mean of item 9. Note also that the significant decline could also be due to their inability to access the website satisfactorily from their homes in 2003. The improved capability of *Getsmart,* included the incorporation of a database on the website that monitored student progress and participation. This increased capability posed a problem for some students. Many students had dial-up connection to their providers which slowed down or halted the downloading process to their computers.

In 2003, the website had the online activities and experiments with worksheet download options. Students, who downloaded, completed and handed in worksheets for comments, probably did not need to send emails because their concerns were addressed though other means. The availability of an email option, gives students a channel through which they can ask questions and seek answers until their queries have been clarified (Tobin, 1997). The idea is for the students to send questions as they arise, without having to wait for the next lesson or another opportune moment with the teacher to raise the question. If, though, students do not have the motivation to make use of this opportunity, then there is little more that the technology or the teacher can do. This evokes the same enquiry, do they know how to express their concerns in an email?

The decline in the mean of item 15 - "Other students respond positively to questions in relation to Internet lessons" is probably explained by the groups' general decline in interest in not just physics but school activities as a whole. (This is supported by qualitative data in the next chapter). When these students were surveyed, they had less than three months remaining to complete high school. This group of students was probably reaching a stage where they were just tired of school and were doing enough to complete their schooling requirements. The work loads of other subjects in term three probably also prevented students from showing excessive enthusiasm about such activities.

The results of the WEBLEI in Year 12 Physics shows that while improvements to the website did not produce corresponding changes to students' perceptions; nonetheless students still had positive perceptions of their learning environment. Even more than a year later, one group of students in this study had almost the same perception across three of the four WEBLEI scales. The exclusion of some interactive activities appeared to have lowered students' perceptions for the Interaction scale.

7.4.2 Perceptions of the learning environment in Year 10 Advanced Science

In 2003, Year 10 Science at the school where the research took place was significantly overhauled. Unlike previous years when science was compulsory at this level, in 2003 those students who had successfully completed all the pre-requisite requirements of the subject could choose their science options in the first semester. In the second semester, they could opt for no science at all. The other significant change was that the time allocated to science classes was reduced from 201 to 134 minutes per week. Two advanced science classes participated in this study. It was the first time that a web-based learning approach was attempted in a class with shortened teaching time. The results of the WEBLEI survey were compared with the Year 10 Science results of 2002. These results are listed in Table 7.13.

Table 7.13

Descriptive Statistics of the WEBLEI Scales based the on Junior Science Classes (2002) and Advanced Science Classes (2003).

WEBLEI Scales	Descriptive Statistics						
	Mean			Standard Deviation		Valid Cases	
	Year 10 Science (2002) (1)	Advanced Science (2003) (2)	Difference in means (1)-(2)	Year 10 Science (2002)	Advanced Science (2003)	Year 10 Science (2002)	Advanced Science (2003)
Access	3.95	4.13	- 0.18	0.63	0.52	177	44
Interaction	3.51	3.58	- 0.07	0.73	0.50	175	46
Response	3.78	3.69	0.09	0.71	0.74	178	43
Results	3.90	4.09	- 0.19	0.63	0.58	175	45

Advanced science students in 2003 chose the subject, whereas the Year 10 students in 2002 were in a compulsory subject. *Getsmart* was also improved from the previous year. This class had a mix of more academically capable students than a normal science class. Many of these students were opting for senior physics, chemistry, and biology in year 11. As shown in Table 7.13, students in this group also had higher means on three of the four scales than science students on 2002, but none of these differences was statistically significant ($p<0.05$). The two classes had different teachers (one of the classes was taught by the researcher). Further data analysis was performed to see if there was a variation between the classes (Table 7.14).

Table 7.14

Descriptive Statistics of the WEBLEI Scales based the on Advanced Science Classes (2003).

WEBLEI Scales	Descriptive Statistics						
	Mean			Standard Deviation		Valid Cases	
	Advanced sci.A (1)	Advanced sci.B# (2)	Difference in means (1) – (2)	Advanced sci.A	Advanced sci.B#	Advanced sci.A	Advanced sci.B#
Access	4.00	4.24	- 0.24	0.44	0.56	21	23
Interaction	3.59	3.57	0.02	0.50	0.50	19	27
Response	3.50	3.83	- 0.33	0.68	0.76	18	25
Results	3.86	4.25	- 0.39*	0.66	0.44	19	26

Taught by the researcher.
*$p<0.05$

The results of the survey in these two classes were somewhat unusual. Compared with advanced sci.B, students in advanced sci.A had a mean which was lower in three of the four scales. In this instance, there was a significant effect for the Results scale, $t(29) = 3.16$, $p<0.05$, with the students recording a higher mean in advanced sci.B than in advanced sci.A. The Results scale gave an indication of the students' perceptions of the end result of their online experience.

The difference in the Response scale was also noticeable, even though it was not statistically significant. Students in advanced sci.B scored a higher mean than students in advanced sci.A. The Response scale gives an indication of how students felt about their online learning experience. It was notable that these students also participated in the *Online Learning Environment Survey* (OLES) (at about the same time as they completed the WEBLEI. The results showed some variations between the classes, but for the Enjoyment scale of OLES, the means score of advanced sci.A class was significantly lower than advanced sci.B (Trinidad & Chandra, 2003). This result supported the findings of the Response scale which gives an indication of how students felt. In this instance, one class (advanced sci.A) did not enjoy the online experience as much as the other (advanced sci.B). Hence, they did not feel as good as the other class. The difference between the means and the relatively high standard deviation for some of the scales required further analysis. The ratio of boys to girls was 3:2 and a statistical analysis was conducted to see if the variation could be explained by this gender difference (Table 7.15).

Table 7.15

Descriptive Statistics of the WEBLEI Scales Based on the Responses from Boys and Girls in the Advanced Science classes (2003).

WEBLEI Scales	Descriptive Statistics						
	Mean			Standard Deviation		Valid Cases	
	Boys (1)	Girls (2)	Difference in means (1) – (2)	Boys	Girls	Boys	Girls
Access	4.18	4.05	0.13	0.47	0.59	28	16
Interaction	3.57	3.62	-0.05	0.49	0.51	30	16
Response	3.67	3.73	-0.06	0.75	0.75	29	14
Results	4.12	4.01	0.13	0.48	0.75	30	15

As shown in Table 7.15, the boys scored higher means on two (Access and Results) of the four scales. These differences were not statistically significant ($p<0.05$). The standard deviations for the Response and Results scales were high which suggested some variation in students' responses. A proportion of students in these classes were from Non-English speaking backgrounds, predominantly from South-East Asia. Rickards (1998, p. 151) pointed out that "cultural backgrounds of students in a class has been shown to have an influence on how students perceive the learning environment." A statistical analysis was performed to differentiate between boys and girls on the basis of their backgrounds. Students were divided into four groups – Boys (Non-English speaking and others) and Girls (Non-English speaking and others) and the results are presented in Table 7.16.

Table 7.16

Mean and Standard Deviation of WEBLEI scales for Boys and Girls from Non-English Speaking and Other Backgrounds (NESB) in Advanced Science in 2003.

WEBLEI Scales	Descriptive Statistics					
	Mean		Standard Deviation		Valid Cases	
	NESB	Others	NESB	Others	NESB	Others
			Boys			
Access	4.34	3.95	0.36	0.78	10	19
Interaction	3.73	3.48	0.61	0.43	10	20
Response	4.05	3.47	0.43	0.81	10	19
Results	4.30	4.04	0.41	0.49	10	20
			Girls			
Access	3.37	4.03	1.15	0.67	6	12
Interaction	3.47	3.70	0.42	0.57	6	10
Response	2.33	3.60	1.00	1.17	6	12
Results	3.08	4.07	0.93	0.86	5	12

Table 7.16 reveals valuable results. It shows four distinct groups of students in the two classes. Boys (Non-English speaking) dominated all four scales, followed by Girls (others), Boys (others) and Girls (Non-English speaking). (In this case Non-English speaking students were those who were born in South East Asian countries. Others represented the rest of the population.). With the exception of the girls from Non-English speaking backgrounds, all other students agreed with the items in the Access and Results scales because the means were either close to or greater than four. What is noteworthy is that girls from Non-English speaking backgrounds were the only group of students in this study who disagreed with the items in the Response scale. Therefore, these students did not feel positively good about their web-based learning environment. The standard deviation across all four scales for girls was comparatively larger. There was a wider variation in their responses. A profile (Figure 7.2) of the means (for each group) against the WEBLEI scales reveals four

distinct patterns. None of the profiles intersected each other. While the means of the WEBLEI scores from three of the groups produced a sketch that was consistent with other sketches in this study, a similar plot for girls from Non-English speaking backgrounds was unique.

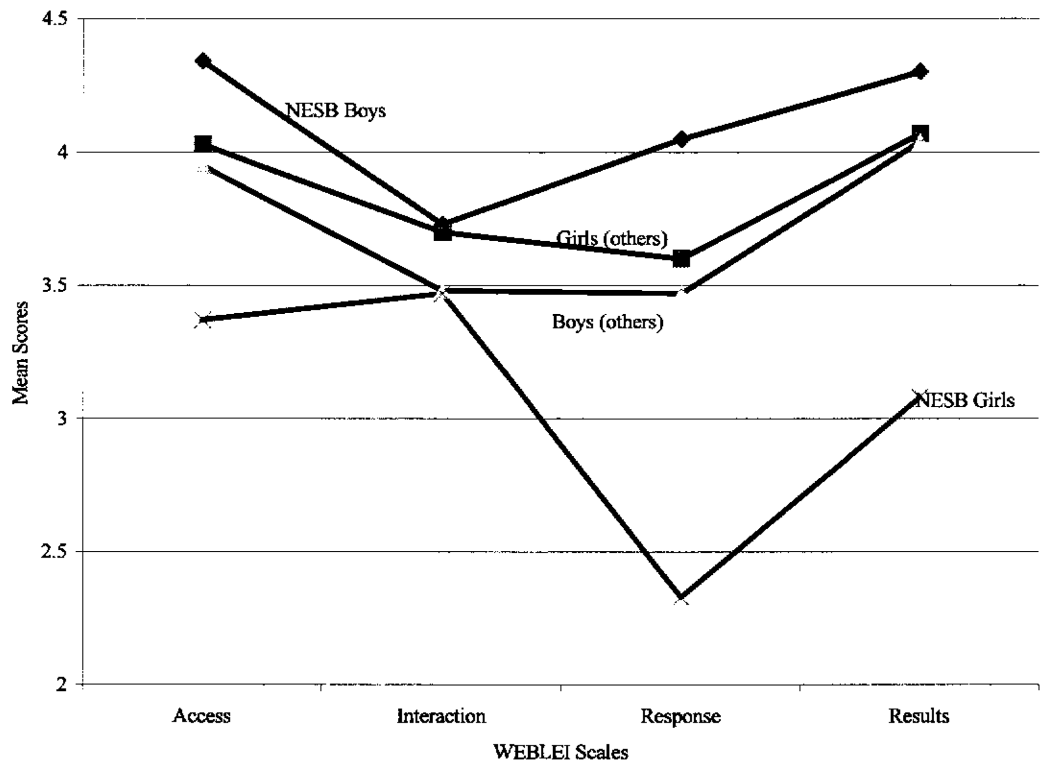


Figure 7.2. Profiles (Actual) of Mean WEBLEI Scores for advanced science students (2003). (The means were calculated on the basis of gender and students' backgrounds.)

The sample size in this instance was small; hence, the results cannot be generalized. The development of websites such as *Getsmart* is often meant to help students who may not gain the most from conventional teaching methods. The researcher's experience has been that students from migrant backgrounds generally have difficulties with the curriculum, language, and the classroom environment especially for the first few years. While, *Getsmart* had met the expectations of boys from Non-English speaking backgrounds, it did not have the same level of success with the girls. Qualitative methods revealed further evidence for these variations. This issue is revisited in Chapter Eight.

It was also worth noting that the time for science in these classes was reduced by one third (in comparison to previous years). While in 2002, students had 31 minutes allocated for web-lessons and approximately 165 minutes for in-class activities, in 2003, they had 31 minutes for web-lessons and 103 minutes (approximately) for traditional lessons. In 2003, when students were switched to the blended learning approach, they only had 60% of in-class time when compared with students in 2002. For students who disliked web-based learning and preferred the traditional approach, such a change could have a significant impact on their perceptions of the learning environment.

In a cross-national study on learning environments with students from Australia and Taiwan, Aldridge and Fraser (2000) reported that students in Taiwan held their teachers in high esteem. They either rarely or never questioned their teachers' knowledge or their teaching methods or the lesson content. Obviously, the absence of such a figure from a classroom can influence perceptions of students who have grown under these conditions. It is also important to note that Aldridge and Fraser (2000) used the WIHIC questionnaire and found that students in Taiwan were less likely to be involved or be task oriented when compared with Australian students. Both these characteristics are essential for web-based learners. However, Aldridge and Fraser's research did not elaborate on the difference between boys and girls. Similarly, Rickards (1998) reported that students from a South-East Asian background perceived their teachers more positively on three scales; Leadership, Helping/Friendly, and Understanding. All these scales emphasised the values associated with the physical presence of a teacher. However, Rickards' (1998) research did not differentiate between boys and girls.

7.4.3 Perceptions of the preferred and actual learning environments

The perceptions of the preferred learning environment gives an indication of what the students theoretically perceive their learning environments to be. This survey was carried out with the Year 12 Physics class in 2003. Half of the student population had accessed *Getsmart* for two consecutive years at various times. The findings of this survey are listed in Table 7.17.

Table 7.17

Mean and Standard Deviation of the WEBLEI Scales (Preferred and Actual) for Year 12 Physics Students in 2003.

WEBLEI Scales	Descriptive Statistics						
	Mean			Standard Deviation		Valid Cases	
	Actual	Preferred	Difference	Actual	Preferred	Actual	Preferred
Access	4.10	4.22	0.12	0.43	0.77	30	30
Interaction	3.44	3.97	0.53*	0.45	0.78	30	30
Response	3.58	3.98	0.40*	0.54	0.73	30	30
Results	4.03	4.26	0.23	0.43	0.76	30	30

** $p < 0.05$.

As expected, students' perceptions of their preferred web-based learning environment were higher than the actual environment (Table 7.17). While the means were higher for all scales, only two of the differences were statistically significant when the paired samples t-test was applied. The effect was significant for the Interaction ($t(29) = 3.75$, $p<0.05$) and the Response scales ($t(29) = 2.98$, $p<0.01$) which had higher means for the preferred environment. It is also worthy to note that while there was a higher mean for the Access and Results scales, these differences were not statistically significant. Hence, the characteristics ascertained by the Access and Result scales had almost met student expectations. A profile of the two sets of results is shown in Figure 7.3.

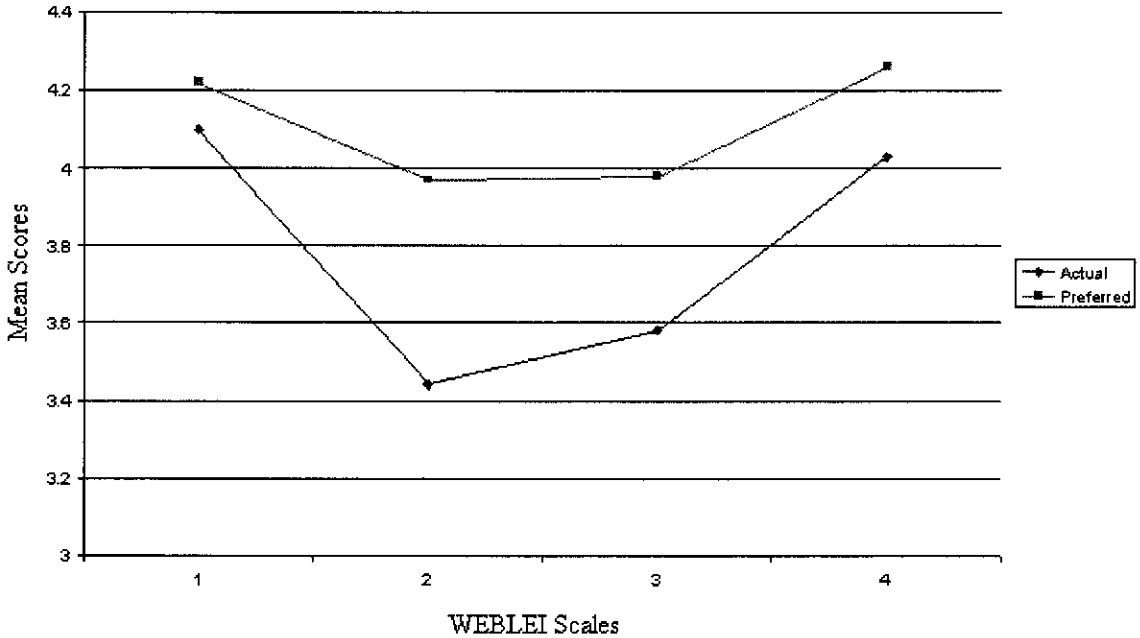


Figure 7.3. Profiles (Actual and Preferred) of Mean WEBLEI Scores for Physics students.

A closer examination of these scales revealed the items which had variations in their means that were statistically significant. A paired samples t-test was carried out on the individual items of the actual and preferred surveys for each respondent. For the Access scale, the difference in the means of none of the items was statistically significant ($p < 0.05$). For the Interaction scale, items 9, 12, 13, and 16 had higher means which were statistically significant at the levels shown:

9. I communicate with my teacher in this subject electronically via email.

   ($t(29) = 5.6, p<0.01$)

12. I feel comfortable asking my teacher questions via an email.

    ($t(29) = 2.1, p<0.05$)

13. The teacher responds to my emails.

    ($t(29) = 4.2, p<0.01$)

16. I can ask other students what I do not understand during computer lessons.

    ($t(29)= 4.1, p<0.01$)

Statements 9, 12 and 13 are interconnected. If students do not feel comfortable sending emails, they are most unlikely to communicate with their teacher electronically. Consequently, they are most unlikely to have a response from their teacher. These results suggested that students would prefer to send emails and interact in this manner. However, all these items reflect aspects which are student driven. The teacher and the technology can create opportunities, but it is the learners' responsibility to utilise it.

A paired sample t-test for the items in the Response scale showed that for items 17 and 23, students had higher means for their preferred environment survey; these were also statistically significant:

17. This mode of learning enables me to interact with other students and my teacher. ($t(29) = 3.1, p<0.05$)
23. The web-based learning environment held my interest in this subject throughout this term. ($t(29)= 3.5, p<0.05$)

Item 17 is also linked to student motivation and the desire to use the opportunities available to them. Perhaps in this instance students believed that they could do more in terms of interacting with their peers and their teachers. In the Results scale, the difference in the means of Items 26 and 27 were statistically significant. The means for the preferred environment were higher.

26. The organisation of each lesson on the Internet is easy to follow. ($t(29) = 2.3, p<0.05$)

27. The structure of the lessons on the Internet keeps me focused on what is to be learned. ($t(29) = 3.5, p<0.05$)

The findings of the two items indicate that the some of the lessons on the website probably need to be made more user-friendly. The addition of more interactive options in some of the lessons may keep students focussed on the lessons. For an evolving website such as *Getsmart,* such findings are to be expected.

7.5 FINDINGS OF THE WEBLEI

A total of 406 students in 15 classes used *Getsmart* in 2002 and 2003. From this sample, 72% of the students returned their completed surveys. Some of the students chose not to respond to certain items in a scale. Hence, such responses were not considered to be valid cases for that scale only. The data from these surveys were used for the analysis presented so far. The impact of various factors such as gender, subject, academic outcomes, and student backgrounds have been explored to establish their possible connection with the WEBLEI results.

Table 7.18

Mean and Standard Deviation of the WEBLEI Scales (Actual) for the Samples in 2002, 2003 and the Whole Sample.

WEBLEI Scales	Descriptive Statistics								
	Means			Standard Deviations			Valid Cases		
	2002	2003	Whole Sample	2002	2003	Whole Sample	2002	2003	Whole Sample
Access	3.99	4.11	4.02	0.61	0.48	0.59	208	75	283
Interaction	3.58	3.52	3.53	0.71	0.48	0.71	206	80	286
Response	3.80	3.65	3.81	0.68	0.66	0.67	209	74	283
Results	3.94	4.07	3.98	0.60	0.52	0.58	206	74	280

The table above shows that over the two years, the results obtained were comparable. For the Access scale, there were means of 3.99 (SD = 0.61) and 4.11 (SD = 0.48) in 2002 and 2003 respectively. For the Interaction scale, a mean of 3.58 (SD = 0.71) was achieved in 2002 - this fell marginally to 3.52 (SD = 0.48) in 2003. Similarly, for the Response scale the means fell from 3.80 (SD = 0.68) in 2002 to 3.65 (SD = 0.66) in 2003. The mean rose slightly in 2003 to 4.07 (SD = 0.52) from 3.94 (SD = 0.60) in 2002. While there were some differences, none of these variations were statistically significant ($p<0.05$). Overall, the means in each scale for the entire sample appeared to suggest that the students:

a) Agreed that *Getsmart* and web-based learning were efficient and offered them convenience and autonomy. This was based on the fact that the overall mean for the Access scale was 4.02 (*SD* = 0.59) which pointed to a high level of agreement with the characteristics of this scale.

b) Agreed to varying degrees that such an approach to learning enhanced interaction. The mean for the Interaction scale was 3.53 (*SD* = 0.71). Many students in this sample did not feel comfortable sending emails to their teachers'. Such an attitude can influence the results because four out of the eight items dealt with emails. Qualitative data revealed that there was interaction more with the Internet technology rather than with other participants in the course. This is revisited in the next chapter.

c) Agreed to varying degrees with the items of the Response scale. An overall mean of 3.81 (*SD* = 0.67) was calculated where students enjoyed learning via the Internet because it was interesting and more satisfying.

d) Agreed that the website had enhanced their learning outcomes. A mean of 3.98 (*SD* = 0.58) was obtained. The four scales of the WEBLEI are interconnected with each other in an orderly sequence (Chang & Fisher, 1998). The Results scale relies on the other three (in order) and shows whether the students have accomplished any learning objectives through a web-based learning environment (Chang & Fisher, 1998). Figure 7.4 shows a profile of the means for each scale in 2002, 2003 and the overall mean.

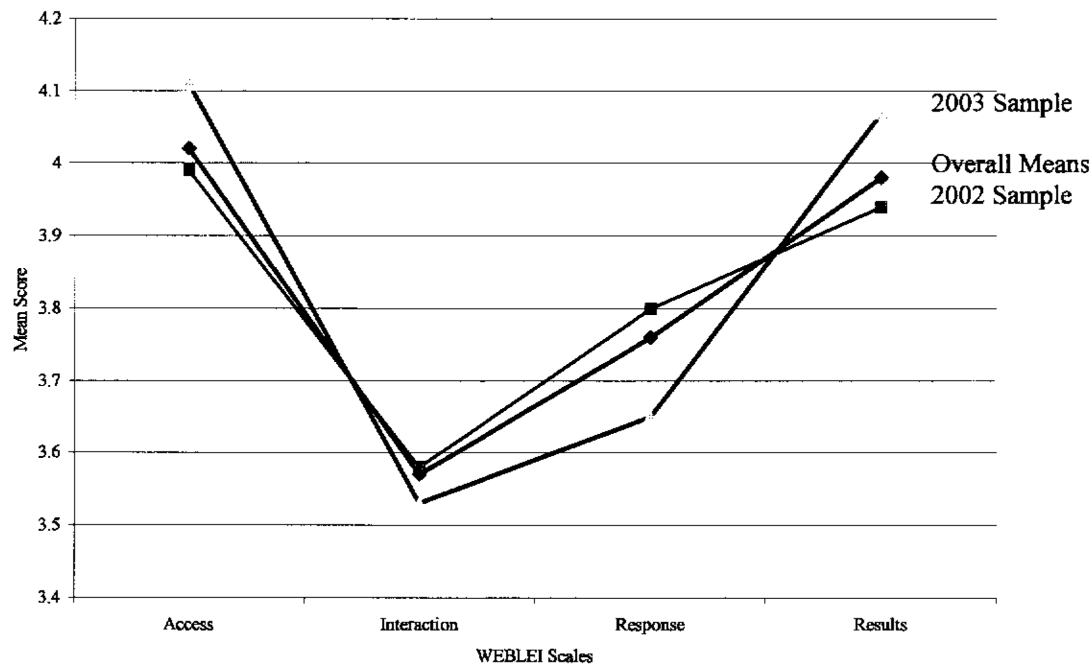


Figure 7.4. Profile of the means the WEBLEI scales for all students from the 2002 sample, the 2003 sample and the sample overall.

While the field of learning environments research is alive and thriving, research in some disciplines has questioned the assumptions on how such research is carried out (Roth, 1999). Roth pointed out that two things underlying the use of learning environment instruments need to be questioned. Firstly, according to Roth (1999), new research in diverse areas found it was virtually impossible to create unambiguous statements on which learning environment instruments were designed. Secondly, he also pointed out that "common sense can be presupposed only to the extent that shared experiences of readers" were common (Roth, 1999, p. 229). He further noted that two students in two different educational settings may not interpret such statements the same. Both of these problems indicated by Roth are worthy of closer examination.

There is no doubt that statements can be ambiguous and can be interpreted differently because human beings are complex creatures. They think and act differently. For example, study item 12 on the questionnaire: "I feel comfortable asking my teacher questions via email." In a sample of 291 students, the average score for this item was 3.34 (*SD* = 1.27), an implication that students neither agreed nor disagreed. There is no doubt that some students would have interpreted the statement incorrectly and extrapolated the meaning of the statement in some ambiguous manner. Is this result suspicious because some students might have interpreted the statement incorrectly? There has to be a point where the intellectual judgment and comprehension of readers has to be trusted, otherwise society as a whole will question the accuracy of the comprehension of all written documents.

As discussed in previous paragraphs regarding the Interaction scale, items 12, 9, 13 and 11 appear to be connected with each other in this order. The mean of item 12 ($M = 3.34$, $SD = 1.27$) probably suggests that students did not feel comfortable sending their teacher an email. In item 9, "I communicate with my teacher via email", the mean was 3.23 ($SD = 1.30$), in 13, "The teacher responds to my emails", it was 3.18 ($SD = 1.15$) and in 11, "I have the option to ask my teacher what I do not understand by sending an email", it was 3.68 ($SD = 1.20$). These values suggest that in the research sample, students were unsure (neither agreed nor disagreed) if they felt comfortable sending emails to their teacher, thence they did not communicate electronically. Consequently, their teachers did not respond to emails if they did not receive any. However, they generally agreed with statement 11 ("I have the option to ask my teacher what I do not understand by send an email.") The correlation between the scoring of these statements was also positive and significant ($p<0.01$) which is further evidence that students responded similarly to the four statements (Table 7.19).

Table 7.19

Pearson Correlation between Items 12, 9, 13, and 11.

Item	Pearson Correlation			
	Item 12	Item 9	Item 13	Item 11
		Valid cases (n = 290)		
Item 12	-	0.47**	0.52**	0.64**
		Valid cases (n = 290)		
Item 9	0.47**	-	0.37**	0.50**
		Valid cases (n = 290)		
Item 13	0.52**	0.37**	-	0.52**
		Valid cases (n = 291)		
Item 11	0.64**	0.50**	0.52**	-

** Correlation is significant at the 0.01 level (2-tailed).

The positive correlation between the scoring of these items (Table 7.19) together with comparable means implies that ambiguity in the wording of these items was not a factor in the use of the WEBLEI. All the correlations were significant ($p<0.01$). Additionally, students in the researcher's Year 12 Physics (2003) class where asked to elaborate on their answers. These students had the most exposure to this approach. One significant response was to items relating to emails. Students explained their response to item nine as follows:

I agree that I can communicate via email but prefer to have my questions answered face to face.

I didn't communicate via email because there might be a pause of one day before a response, in which case I would have already forgotten my problem.

I don't like the email all that much and if I don't understand something, I'd rather talk to someone face to face.

In a blended learning approach, students have the best of both worlds. Obviously, if they like to ask questions "face to face" and such an option is readily available, then students are likely to take this. Item 24; "I felt a sense of boredom in this subject towards the end of this term" was also relatively low scoring (M = 3.21, SD = 1.25) so boredom was an issue. This was not necessarily subject related as the students explained:

I was more stressed than bored, so I just couldn't be bothered. I gave up half way through the term.

I did not enjoy learning as much as I did last year over all my subjects.

To be honest, Physics isn't my best/favourite subject and I guess after two years of it, my enthusiasm had dulled.

The topics under discussion failed to hold my interest for long.

Roth (1999, p. 231) argued that the use of "existing re-presentations (instruments, discourse, they are embedded in) got in the way of a concerned understanding of students' experientially needs." In this research, the findings have been interpreted differently. Instead, of the WEBLEI impeding, it has demonstrated its usefulness. It has shown, for instance, that the universally held belief that emails increase the interaction between learners and educators requires more research for the sample in this study. The belief that such technological options will bring positive changes (Shneiderman, 2002) cannot be taken for granted.

7.6 CHAPTER SUMMARY

The use of learning environment instruments should be supported by quantitative research (Fraser, 1994). Tobin (2000) pointed out that learning environments research was still primarily based on the findings of learning environment instruments. Research findings based on one method can be unreliable because "there are strengths and weaknesses in any single data collection strategy" (Patton, 1987, p. 60). The use of more than one "data collection approach permits the evaluator to combine strengths and correct some of the deficiencies of any one source of data" (Patton, 1987, p. 60). Triangulation "increases the strength and rigor of an evaluation… by building checks and balances into a design through multiple data collection strategies" (Patton, 1987, p. 60). Denzin (1978) listed four ways in which triangulation can be achieved. In this study two of the four ways proposed by Denzin are employed namely – *data* and *methodological* triangulation. Triangulation was achieved with the WEBLEI initially setting the tone. Checks and balances to the data generated by WEBLEI were achieved through the qualitative methods. These methods also provided construct validity to the WEBLEI scales. In Chapter Eight, student's perceptions of their blended web-based learning environment are explored by examining the data gathered qualitatively.

CHAPTER 8

STUDENTS' PERCEPTIONS OF A WEB-BASED LEARNING ENVIRONMENT BASED ON QUALITATIVE FINDINGS

8.1 INTRODUCTION

In the previous chapter, the results generated from use of the WEBLEI were discussed. The WEBLEI presented a very positive picture of blended web-based learning that formed the focus of this research. The data also suggested that the design and implementation of *Getsmart* had led to positive perceptions amongst students. The WEBLEI is a learning environment instrument which produced quantitative data. However researcher's, such as Roth (1999), have argued that the use of learning environment instruments does not paint the full picture of learners' experiences. Discrepancies have been found between questionnaires and textual data collected through interviews and written answers. In his research, Tobin (1998) abandoned learning environment instruments and used a hermeneutic approach that enabled him to encapsulate the voices of the learners.

In this study, qualitative data were gathered and analysed to determine the extent to which they supported, contradicted or added to the findings generated by the WEBLEI. One of the key aspects of qualitative research is that it produces findings which were reflective of participants' thoughts of new programs or initiatives (Patton, 1987). Patton also pointed out that the use of more than one data collection method permitted researchers to combine the strengths and correct some of the deficiencies which existed in various techniques. Tobin and Fraser (1998) also believed that complimentary insights could lead to improved outcomes in research.

Qualitative data were collected mainly through written surveys, emails, and analysis of online chats. Concisely, this chapter explores the impact of a web-based learning environment on students' perceptions by analysing these qualitative data. Where possible, connections between the qualitative data and the four scales of the WEBLEI have also been made. The findings from emails is presented initially (8.2), followed by the findings from written surveys (8.3) and online chats (8.4). The second last section of this chapter (8.5) discusses the key findings of both methods with some suggestions for improving the design of the WEBLEI. A chapter summary is also presented (8.6).

8.2 FINDINGS FROM EMAILS

A total of 171 emails were sent by students. Apart from asking course-related questions, students expressed their views not only on the website as it was, but also on how it could be improved. With the exception of one email, all were highly positive. The use of this process created a unique opportunity for students to comment on their learning. A variety of different opinions was expressed and the majority of them saw the value in this type of learning. The quality of their responses reflected the quality of the participation by the learners. The design of *Getsmart* was guided by the principles of cognitive apprenticeship. Hence, within these responses, evidence of activities which demonstrate evidence of the instructional methods of cognitive apprenticeship (discussed in Chapter 5) was also sought. The emails were categorised on the basis of the four WEBLEI scales and beyond.

8.2.1 Evidence on the Access scale

The design of the WEBLEI was based on the work of Tobin (1998) who used an Internet application called Connecting Communities of Learners (CCL) with his students. He reported that accessing learning materials at students' convenience was crucial to the success of the online learning initiatives. In this study, student emails suggested that these qualities were also important to them. They found that accessibility after school was an advantage.

I think that if you miss a class at school, for example, you were sick then you can go on the net and obtain the information that you missed. It is a very helpful tool.

Year 12 Physics student (male)

I use it after school if I have trouble with my work.

Year 11 Physics student (male)

Another important aspect of this approach was that it enabled learning to occur at the students' own pace.

It is more convenient to learn at your own pace and at a time convenient to you.

Year 12 Physics student (male)

Getsmart is a clever site that allows us to learn science independently and to experience different types of teaching and learning. It has all the information we need to understand the science we are learning. I prefer it to being taught in a classroom because you can learn at your own pace.

Year 10 Science student (female)

8.2.2 Evidence on the Interaction scale

Tobin (1998) argued that a very important characteristic of developing a community of learners was that they should have the option to ask if they do not understand something. According to Tobin (1998), such an option should be available until issues are clarified. While the results from the WEBLEI suggested that students did not feel comfortable sending emails, the variety of emails received showed the quality of the interaction that occurred.

Chat sessions were available to students in 2002 senior physics classes. An in-depth analysis of one of these sessions is presented in section 8.4. Chat sessions were meant to enhance interactions through instructional methods such as scaffolding, articulation, reflection, and coaching. The comments below demonstrate evidence of coaching and scaffolding in these sessions.

I must admit, however, that the chat sessions were quite helpful. It forced me to keep up with the work being covered in class and presented some more stimulating questions.

Year 12 Physics student (female)

The after-school chat tutorials were quite helpful in REINFORCING what we had learnt already.

Year 12 Physics student (male)

Another aspect of interaction that was sought within the cognitive apprenticeship framework was that online learning should provide students with opportunities for questioning and scaffolding. For instance in the email below, a student expresses her concerns about her answer which was marked as incorrect by the computer:

In the lesson on Refraction, I would like some clarification on the following question - In the diagram above (diagram not reproduced), what is the correct ascending order of the refractive indices of the five media?

(a) 2, 3, 5, 1, 4

(b) 4, 1, 3, 5, 2

(c) 2, 5, 3, 1, 4

(d) 2, 5, 3, 4, 1

(e) 4, 1, 3, 2, 5

I chose (b) because it is from least dense to most dense. I thought the denser the object, the higher the refractive index. I also thought ascending means from the smallest to the largest number.

However, the answer is (c).

Please tell me what's wrong with my choice.

Year 11 Physics student (female)

Another used emails to seek further support after school:

I've worked the revision questions from the website. I'm having some difficulties with the more difficult questions at the end. I was wondering if it's possible that I could meet you tomorrow after school and work on the questions then. Sorry to do this on such a short notice.

Year 11 Physics student (male)

Some researchers believe that applications in which the process is more important than the answer is probably more rewarding to the learners (Jensen, 1998). Questioning "the what" and "the how" of their learning is an important aspect of this process. Such an opportunity is present in traditional classes but it is often dominated by a handful of students. Some students may feel threatened about asking questions for a variety of reasons (such as ridicule from other students). Jensen (1998) pointed out that the first step in engaging learners and uncovering their intrinsic motivation was to eliminate threat. Emails create a unique opportunity for students to question aspects of the teaching approach in a non-threatening environment. In this study, positive suggestions and constructive criticism were made in terms of what the problems of online learning were and how these could be resolved. Issues raised included the interactivity aspects of the webpages.

The overall layout of the site is very dull, so one would quickly lose interest if it were not for some of the multiple-choice tests and the chat room. Suggestions for improving the site include using software such as Flash and or Java to improve the interactivity and the look of the site.

Year 12 Physics student (male)

If it is possible, the website should include animations of theories, diagrams, and so on, as I find them easier to understand.

Year 11 Physics student (male)

Students also made suggestions about the quality and quantity of the exercises included in the website. Such a level of interaction suggested that they saw themselves as significant partners in the teaching and learning process. How many times in a traditional classroom do students have opportunity to comment on teaching practices? Examples of students' remarks included:

More complex reasoning style questions should be put on a webpage within the site... Short Answer questions marked by you personally via email would also greatly improve the functionality of the site.

Year 12 Physics student (male)

Getsmart has been of great assistance to us all in semester 1. However, I believe that your site can help the students achieve at an even better level if there are more exercises we can work through after each Internet lesson.

Year 10 Science student (male)

The website is good but there should be more than one test per each topic.

Year 11 Physics student (male)

The inclusion of more examples and additional links to other sites was another idea that students proposed.

I enjoyed using the online tutorials and I think it was beneficial to my learning as well. I think the site could be improved by adding more examples with their solutions, and also with more links to other sites.

Year 12 Physics student (male)

As in a traditional classroom, students identify problems if there are any. Through emails, students pointed out errors and suggested how these could be fixed.

There is an error on the Scalars and Vectors Test page (Question 1)
Which one of the following is a scalar quantity?
(a) deceleration
(b) velocity
(c) force
(d) momentum
(e) speed
The computer's answer is (d) momentum, when it should be (e) speed, because speed is a scalar quantity and momentum is a vector quantity.

Year 11 Physics student (male)

In the test for conservation of momentum, question 3 has west as an option where it should be east. I might not be correct but I thought I should tell you in case.

Year 11 Physics student (male)

A number of other responses gave the teacher an insight into how their learning was progressing overall.

I was just wondering if we needed to know all of that stuff about short and long sightedness' for example, Myopia for short sightedness and Hypermetropia for long sightedness, etc. because Z, S* and I had no idea what the question was talking about.*

Year 11 Physics student (female)

I would like some help with acceleration, the third example in particular.

Year 10 Science student (female)

8.2.3 Evidence on the Response scale

Research into the human brain suggests that an enriched learning environment stimulates the connection between brain cells which possibly increasing the brain's capacity to learn (Jensen, 1998). *Getsmart* was developed as an enriched learning environment and was based on the electronic cognitive apprenticeship model (Collins, Brown, & Newman, 1989; Wang & Bonk, 2001). The feelings of learners in such environments are important because they reflect the quality of the enriched learning environment. Emotions and feelings go hand in hand. According to Jensen (1998, p. 79), "emotions are not the cards on the table but the table itself" and good learning "does not avoid emotions, it embraces them." The Response scale of the WEBLEI was aimed to quantify how students' felt in this type of learning environment (Chang & Fisher, 1998). It was designed to capture students' feelings and emotions, but there is a limit in terms of how many feelings and emotions can be captured in eight items. Like all other scales, the Response scale of the WEBLEI, had eight items. Student email responses gave another insight into these emotions. They felt that the website had a good balance of text and graphics and was useful for exam preparation.

I think educational webpages should focus on being concise and have mainly content rather than focus on pictures to grab attention. I value this because I would only go to an educational site if I want to actually learn something. I think graphics should only really be used for diagrams to help teach the information. Your web site has a balance of both information and appropriate graphics, which is good.

Year 12 Physics student (male)

I have found that the information on the web pages to be useful in my exam preparation, because it goes into more depth in some cases than the text.

Year 12 Physics student (female)

Any activity that offered choices and was relevant and engaging was likely to capture student attention for an extended period of time (Jensen, 1998). For this to occur, learners should have a minimum of distractions and they should enjoy the experience. Numerous responses highlighted these feelings.

I believe the e-learning concept of lessons accessible after school hours to be a great idea. It meant the option of learning at my own pace with no distraction of friends and to be able to access the web site when I like and be as comfortable as I want.

Year 12 Physics student (male)

We think your program is an excellent way to learn as it is not so boring.

Year 10 Science student (female)

Getsmart is a useful website for learning science and I have to say that not many teachers do things like this for their students.

Year 10 Science student (male)

I thought the site is pretty good. It is interesting and I enjoyed doing the work sheets. I prefer doing the work sheets and work from the computer, than to be in the classroom doing it.

Year 10 Science student (female)

This site is great because it makes science easier to learn and it is much more interesting than your writing it up on the board. It is also less boring than working in class.

Year 10 Science student (male)

I have found your webpages a pleasant change from ordinary lessons. I think it is well structured and I believe that this method of teaching is interesting and more enjoyable than classroom lessons. The feel in the computer room is more laid back and there is less stress on everyone. I don't think there is much to be improved on this site. I think it is quite a comprehensive study guide.

Year 10 Science student (female)

I like your website. It is good.... at least we use the computers and do not sit in boring science!!

Year 10 Science student (female)

8.2.4 Evidence on the Results scale

The quality of the results and feedback from an educational program is essential for cognitive development. Jensen (1998) pointed out that our brain is self-referencing since it decides what to do based on what has been done before. Feedback was most effective if it was specific, immediate and involved choices. In designing, the WEBLEI, Chang and Fisher (1998) suggested that the Results scale should indicate whether the students had accomplished any learning objectives through an online learning environment. In this case, students felt that *Getsmart* was an effective learning resource.

Thank you for your efforts in creating the web pages. It helped me to quickly find another source of reference if I didn't understand the text book.

Year 11 Physics student (female)

Your site helped me immensely. It simplified the concepts that are presented in the textbook and explained them in a way that was easy to understand. I found the chapter summaries most helpful.

Year 11 Physics student (female)

Thank you very much for your efforts in the Year 11 optics unit. I have improved significantly by revising with your site. The pictures helped to make the information stick to my brain.

Year 11 Physics student (female)

Your website really helped me...if it weren't for those extra questions my study wouldn't have gone nearly as well as it did....they provided me with new material so I didn't loose focus so easily. Also it pointed me in the right direction for my study.

Year 11 Physics student (male)

Another important aspect of the website was the online tests. Within the cognitive apprenticeship framework, these tests were associated with three instructional methods, namely: articulation, reflection, and performance feedback. Feedback at the end of each test also provided technology-driven scaffolding. Student's responses suggested that these tests were a valuable tool.

The thing I liked about e-learning was the multiple choice tests at the end of each page. By doing them, it was easier for me to learn physics and by seeing which questions were right or wrong.

Year 12 Physics student (male)

I found the website useful for my study of physics outside the classroom. The test pages were of much use as they gave me an idea of which areas I needed to spend more time.

Year 11 Physics student (male)

I would like to, in particular, emphasise to you the significance of the quizzes that follow each Internet lesson. Every time when I have answered something incorrectly on the science quizzes, I would have gone through the Internet lesson I was on and re-did the quiz again and again until I scored perfectly. The quizzes had undeniably helped me gather the information that I needed to know to excel in science and I am positive that I am not the only person who has taken advantage of this marvellous feature of your website.

Year 10 Science student (male)

I think that your website is so cool. It really helps us learn were about science step by step and it's easy to follow. I enjoy doing the quizzes at the end of each lesson because it really shows us how well we're coping with the work.

Year 10 Science student (female)

A series of other responses suggested that the students felt that *Getsmart* made their learning easier.

The idea of e-learning is a very good concept since that is the way the world seems to be moving. It is good to have the opportunity to take advantage of this as it makes it an easier process to learn.

Year 12 Physics student (male)

The unit revision in the end and the individual tests were very helpful for me to practise questions while the notes section made it very convenient to access and review stuff, so thank you for that.

Year 11 Physics student (male)

Hi sir, your website is interesting because instead of copying work off the board, we get the information from the Internet.... it is easier to learn with the computer and it is helping me through science.

Year 10 Science student (female)

This site is really good and I learnt much from this site. It made me more interested in science.

Year 10 Science student (male)

The findings of the fourth scale of the WEBLEI suggested that overall, students agreed with most of the items in this scale. Numerous student responses echoed this finding.

I would just like to say that the Getsmart website has been a great learning tool and has truly had an effect on my learning. Personally, I believe that it has boosted my marks and enabled me to revise at home and access exercises whenever I needed to.

Year 12 Physics student (male)

I think that the website definitely is worthwhile and improved my marks dramatically last term. I used it mainly at school to complete the worksheets, from which I studied "heaps" leading up to the exam and hence did well, but that still came from the website and improved my results.

Year 11 Physics student (male)

You are doing a great job and I am thrilled with my improvement by 30% in the knowledge bit (knowledge section of the exam).

Year 11 Physics student (male)

8.2.5 Findings beyond the WEBLEI

As highlighted earlier, all research methods have their strengths and weakness and the incorporation of a variety of techniques enhances the quality of the findings. While the majority of email responses appeared to support the findings of the four scales of the WEBLEI, a small number of responses highlighted other aspects of a web-based learning environment:

I think that e-learning will eventually become the way of learning in the future.

Year 12 Physics student (male)

A small proportion of students could see the value of this approach to learning but felt that the face-to-face interaction was better suited to their needs. The presence of a large number of students who do not like the web-based learning approach can greatly influence WEBLEI results. Hence, such responses were important:

To be perfectly honest, e-learning has not particularly suited my learning style. As a more hands-on-paper person, I find that generally I am not able to absorb information as well from a computer screen as from a book... All in all, I think that e-learning works well to complement in-class learning, but I do not feel that it can take the place of it. A better understanding of concepts, for me, is obtained by physical interaction with teachers and peers, not interaction with a computer screen.... I encourage you to continue your work on this innovative, futuristic view of education. I believe that a balance between online and in-class learning will work best to optimize educational outcomes.

Year 12 Physics student (female)

There is no substitute for the interaction of a student with a teacher in class and I do not believe that e-learning could ever replace this. I think that e-learning should compliment our classroom learning where the concentration of teaching and learning should be, not on the Internet. I think that e-learning is an excellent innovation and I would like to continue with it but some changes need to be made.

Year 12 Physics student (male)

8.3 FINDINGS FROM WRITTEN SURVEYS

Students' emails presented above appeared to support the results across all four scales of the WEBLEI. Written surveys were also administered in order to collect additional evidence on students' perceptions of their web-based learning environment. Unlike emails, where responses were completely open-ended, in written surveys, students were asked to answer a series of open-ended questions. A total of 292 written responses were received from students in 15 science and physics classes. A total of 214 responses were submitted in 2002 and another 78 in 2003. One group of students, the Year 12 Physics class (the researcher's class) participated in both years. For discussion purposes all the responses were divided into five groups. In 2002 the three groups were; Year 11 and 12 physics and Year 10 science. In 2003, the groups were Year 10 Advanced Science and Year 12 Physics. In each instance, general observations made by the researcher about each group precede the discussion.

8.3.1 Group I: Year 10 Science (2002)

All students who did science in 2002 participated in web-based learning once a week in term 2. These students were in nine classes and taught by seven teachers (two teachers had two classes each). All students in Year 10 in 2002 did science; hence, these classes represented a mixture of students with a variety of abilities. It was pleasing to see that in most instances, classes were on task for the entire duration of the Internet lessons (confirmed by teachers' observations). Some sought even more time to participate in these lessons. In order to gauge students' perceptions of their web-based learning environment, they were asked these questions:

What are some of the advantages of learning via the Internet?

What are some of the disadvantages of learning via the Internet?

Do you have any suggestions for improving the website?

Students' responses highlighting the advantages were clustered into nine main areas. The most significant advantage of such an approach related closely with the Access scale of the WEBLEI. Students believed that their ability to work at their own pace and the convenience of working from anywhere were important. Their ability to read as many times as they wanted and learn a little each time were advantages.

It is easier to understand and comprehend because you can read it at your own pace and you don't have to listen to a teacher mumble on.

You can go over the work again as many times as you like. Having the Internet sheets from class lessons help you revise and study. I can go over and over the parts, I don't really understand until I do. It is easy to read and understand.

Student responses also included other reasons such as *Getsmart* had the information in one spot and the pages were tailored to the work that was done in class. If they had difficulties, students had the freedom of choice and they could go to other websites to find the information. The students also felt that *being able to work at their own pace and knowing that there are more learning areas than just the classroom* were important. They also felt that if *Getsmart* did not have the information they wanted then they could try other sites. Another important aspect of working at one's own pace was according to one student, that it gave *time to soak up* all that was being taught in class.

Interaction was probably the second most significant advantage. While the WEBLEI's Interaction scale predominantly measured students' perceptions on the use of emails, student responses in this instance suggested that their interaction with the technology was more significant to them than interactions with humans via technology. Hyperlinks, links to other websites, online tests, applets, pictures, and graphics were the interactions that were highly valued.

It is easy to follow on the net and the test at the end keeps me-thinking.

Go on links...look at pictures...tests help you know what you need to work on.

Self-test your learning.

Examples... better.... written out.... clear...I learn better visually.

Some students felt that the Internet lessons during school gave them an opportunity to discuss and make comments about the work and they could send emails to the teacher about what they did not understand. They also had an opportunity to learn with friends and could ask other students questions without the teacher telling them to be quiet. The real bonus was that they could do all this without reprimands.

Students also believed that web-based learning made learning easier, interesting, and therefore enjoyable. The Response scale of the WEBLEI measured these qualities. According to students' responses, one of the reasons why they responded positively to web-based learning was that it took them away from the usual routine (instead of doing the same thing repeatedly). In this relaxed environment, they did not have to listen to the teacher *carry on.* Their responses also suggested that they did not have to do much writing or copying off the board and consequently they believed that they learnt more. They were also able to do related activities like *make your own rocket* and they relaxed while they were learning.

Many students believed that the design and layout of the website increased their understanding of the concepts covered in their science lessons. This reflected aspects of the Results scale of the WEBLEI. They felt that *Getsmart* not only reinforced content but helped them to look at the content from a different source. One student claimed that such an approach made the class *open-mined and look into new opportunities of learning.* Another student believed that *Getsmart* improved marks, widened knowledge of science and was more than a normal science lesson.

It is presented in a manner that is easy to follow. You can re-read what you do not understand, is put in a way where the content is…in appropriate categories,…you can find your weaknesses.

Students were also asked to suggest reasons explaining some of the disadvantages of web-based learning. In a very small number of responses issues raised included: the lack of direct interaction; difficulty in understanding the text; insufficient time; sore eyes; and online lessons were boring and unnecessary. However, two issues which concerned almost 25% of the students was the likelihood of being distracted when they were on the net and that the Internet cost them money. Students said that lack of discipline often led them to or had the potential of causing distractions through options such as online games (eg. solitaire), music and other websites like *Hotmail.*

Students in the research sample used the Internet on a user-pay basis. Some believed that *Getsmart* cost them too much and they may need *Internet money* for "a rainy day" when the Internet was needed to complete an assignment in another subject. Is the perception of the students that an assignment is a piece of an assessment and is therefore more important than an online lesson in science? In this study, the cost was kept intentionally low - between five to ten cents per lesson. However, the perception that *Getsmart* was expensive was directly due to student's persistent opening and closing of websites. Despite constant teacher supervision during Internet lessons at school, the control over what students did while they were logged on to the net is (at the best of times) beyond the control of teachers. (To the researcher's knowledge, no computer software has been developed to-date that can monitor this.) Remaining focused is directly related to students' self discipline and the extent to which the website maintained their attention. Each time a user opens and closes a webpage or website, it costs money. Many students have access to dial-up Internet connections in their homes which allow unlimited downloads for a fixed price. In cable or broadband connections, users are charged by the number of megabytes downloaded. Hence, some students have difficulties relating the costs associated with dial-up Internet and broadband connections. Perhaps, students need further training on the costs associated with using the Internet. Nonetheless, the lack of Internet money could have influenced how students responded to the WEBLEI items.

The group was also asked to suggest how the website could be improved. A number of students suggested that the website needed better graphics, more interactive activities, more tests, general improvements to layout and students should not have to pay to use it. Some suggested that there should be more links and information:

It would be great to read extra information (eg. the link to the NASA site). Even if the information is not needed for an exam, it greatly reinforces the concepts in the text.

It was also pleasing to see that a significant number believed that the website did not need any improvement with comments like: *it was good the way it was; Getsmart is the coolest;* and *No suggestions - keep up the good work.*

8.3.2 Group II: Year 11 Physics (2002)

In 2002, there were two classes that studied physics in year 11. Both were invited to participate in web-based learning but only one class chose to do so. This class was taught by the researcher. In comparison with the Year 10 classes, this class had students who chose physics. Consequently, there was a greater desire to do well in the subject. For the qualitative survey, these students also had the same questions as the Year 10 Science students.

According to this group, one of the greatest advantages of this approach was increased access, convenience and the way in which it allowed students to work at their own pace (as expressed by the previous group). Student's responses stated that there was greater appreciation for characteristics of the website that related to the Response and Results scales of the WEBLEI:

You can save time doing multiple-choice questions instead of looking up the textbook. There are links to other websites from which you can learn as well. The presentation of the website helps maintain interest (looks better and brighter and not like the textbooks).

It only takes a few hours to learn about almost everything in optics and achieve good results in the test.

Students in this group felt that there were two disadvantages with the design of *Getsmart*. Firstly, the response to queries was not instant and secondly the web pages did not have all the content covered in the course. There were some suggestions for improvement. Students felt that there should be more interactive activities such as online chats, links, and answers to quiz questions. One student felt that the site did not need any improvement - *Not at present, it is spot on, I will let you know though.*

8.3.3 **Group III: Year 12 Physics (2002)**

The Year 12 physics class in 2002 was a rare mix of students with a good distribution of academic abilities. Most were highly motivated when it came to technology-related activities. There were two physics classes but the researcher's class was the only one that actively participated in web-based lessons.

Students in this class also had to state the advantages and disadvantages of web-based learning. The advantages of web-based learning were similar to those expressed by the other two groups:

Good overview of what needs to be learned for the exam. I can ask questions... in the tutorials. Worked examples on the web show how an answer is obtained.

The web pages serve well in collating the information learnt. The multiple choice questions are good for exam preparation.

More comfortable and relaxed environment, opinions and intellect of classmates assists to learn.

If I don't understand something the first time it is explained in class, I can read about it on the Internet to help me understand. The chat also helps.

Most students did not find any significant disadvantages. One student stated that *there was no pressure to learn and consequently students could become lazy.* In a small number of cases the availability of computers when students needed them after school was problematical. Difficulties included the unavailability of phone lines which did not let students access the net. Students pointed out that parents for business or domestic purposes used phones during times when chat lessons were scheduled. One student suggested that the effectiveness of chat lessons could improve if questions discussed in these sessions were given out sooner so that students *have time to think about them and work on them before chatting about them.*

The inclusion of more questions, interactive activities, and enhanced graphics to improve the aesthetics of the site were also suggested.

8.3.4 Group IV - Year 10 Advanced Science (2003)

In 2003, some of the ideas suggested in 2002 for improving *Getsmart* were enacted. With all groups, students wanted more interactive activities and an overall improvement of the aesthetics of *Getsmart*. Year 10 Advanced Science classes were the first to use the revised website. One significant change discussed in section 7.4.2, was a reduction in teaching time for year 10 science. This placed enormous pressure on teachers and students to complete the work associated with various outcomes of the new science syllabus. While the classes were advanced science, and most students were in these classes because they chose this subject, the students appeared to lack the drive, motivation, and qualities of good advanced science students. Perhaps these classes represented a new breed of science students who were only allocated two-thirds of the class time for science than in previous years. They were on this reduced time allocation from year eight, with fewer opportunities for laboratory work and extension activities. Did this diminish their interest in the subject?

Fifty written responses were received from the Year 10 Advanced Science class. As in previous surveys, in the first question students had to discuss the advantages of online learning. Once again the responses for this question overlapped with responses obtained from the previous groups. More than half of the responses suggested that convenience, access from home, the ability to work at students' own pace, and to be able to visit the information whenever and wherever they were ready to learn, were the most important aspects of this approach. Some students specifically commented on their ability to work on a lesson at home and that they could take charge of their own learning as being real advantages. Not having to carry books around was also important to one student. Another student wrote:

When I am missing notes, I can get them home which is convenient because I can get them exactly when I need them.

These responses suggested that the characteristics of the Access scale were an important aspect of web-based learning. Interaction and characteristics of the Interaction scale were also viewed as an important quality. Students' responses suggested that *Getsmart* was an interactive way of learning. They also felt that feedback and interaction were easier and links to other sites presented a better scope to learning. One student wrote:

If I do not understand the work, I can communicate with the teacher via e-email.

A number of the advantages highlighted aspects of the Response scale of the WEBLEI where students pointed out that they enjoyed the experience because it was interesting, more lively, and an exciting way to learn. Specific responses included:

Do advanced searches...pressing a button is easier and more interesting than flipping through a textbook.

I am able to learn without distractions.

Learning was faster and more fun...

The quality of the results derived through this approach to learning was an important achievement. Hence, the responses echoed characteristics of the Results scale. Students felt that the new way of learning provided them with a change from books and helped them learn. Examples of students' comments included:

New way of learning...no need to write stuff out.

Easier to understand...the content is to the point, there are fewer extras...

Revision sheets and tests helped me to remember the lesson.

Students can have another source where they can gain information. This enables them to have a better opportunity to achieve better results.

Numerous other responses went beyond the WEBLEI scales. For instance, some students believed that the work that was presented online was easier to understand and they could work effectively without a teacher. This approach also gave them more time to discuss the work and they were also able to retrieve up to-date information from other sources. They enjoyed it more than copying notes in the classroom. *Learning faster* was an advantage that was featured through a number of responses. In some other responses, a change from the books and the blackboard was well received by the students.

Almost one quarter of this sample felt that logging in from home was a problem. Technological failure can have an impact on the perceptions of learners of their learning environment (Tobin, 1998). In 2003, additional features (e.g., the inclusion of a database to track student performance) were added to *Getsmart* which impacted on some students who had dial up Internet from their homes. These additions increased the size of the files which in turn increased download times and subsequently slowed down the rate at which files were transferred from the Internet Services Provider. Understandably, such an inconvenience can influence perceptions on how students score items on learning environment instruments. If access is an issue, then interaction, response, and results will all be affected. Staring at a screen gave a small group of students a headache. Some also felt that having no Internet money was a hindrance to their learning. A number of students from non-English speaking backgrounds, had difficulties understanding the contents of the pages, which probably explained their scoring patterns on the WEBLEI (discussed in section 7.4.2). A few students also acknowledged that while emails gave them the option to communicate, the response was not instant which was a disadvantage.

8.3.5 Group V: Year 12 Physics (2003)

The Year 12 Physics classes of 2003 was the other group that used the improved version of *Getsmart*. This group consisted of an interesting mix of respondents. One half had used *Getsmart* in Year 11 and the other half were the ones who were reluctant to use it in 2002. Unlike the physics class of 2002 (Group III), this group consisted of students with predominantly average academic ability in physics. Their technology skills were also average.

As in other classes, students were asked to discuss the advantages and disadvantages of web-based learning. While the responses were relatively similar to previous responses, there were some that were worth noting. Students felt that the idea of being able to download notes was a significant advantage because it was much easier to print out and highlight information than having to handwrite it all. The clarity of the web pages was another important positive issue and as one student pointed out, *With the Internet, notes are provided, with clear and easy to understand diagrams whereas in class learning...is basically listening.* Another student response stated that *you won't embarrass yourself if you don't get something straightway.* A student believed that, *by emailing a teacher it was harder to explain your problem, as opposed to explaining your problem in class and getting an immediate response.* According to this student, this was an important disadvantage. Is this one reason why most students did not use emails to interact with their teachers? Apart from the lack of direct interaction, there were no other significant disadvantages of using emails. One student wrote that there were no disadvantages because they were actually learning something.

These students were also asked to list the features of the website which they thought were beneficial to them as learners. There were seven features which were most appealing to students. These were (in descending order): tests, clear and concise notes (with examples and exercises), revision exercises, clear graphics (pictures and diagrams), links to other sites, online experiments, and the layout of the pages. The feedback from tests actually enabled students to see what they learnt. Other explanations included:

There are diagrams and well-planned notes to help you understand and interpret the work.

I found that the layout of the lessons was very easy to follow and the pages included all the information needed to understand the topic.

The information that was provided as well as the revision sheets/worksheets...aided my learning.

Online experiments were time consuming but a good exercise.

Students were also asked if the website promoted discussion with their colleagues during computer lessons. Of the 24 students who responded to this question, almost 60% stated that it did. A student who believed that *everyone was caught up doing their own thing because they were progressing at varying rates and working on different topics* saw this as one possible reason for the lack of the interaction. Those who had the interaction were relatively positive about the opportunity created by this approach to learning. One student wrote, *I had discussions when summarizing chapters.*

While more than 80% of this group had a reliable Internet connection, one-third of the group claimed to have had some difficulties logging in at times from home. This was also expressed in the responses of some students discussed earlier. A number of students also believed that the website was perfect the way it was. The response of one student summed up the approach to this mode of learning:

The effectiveness of the Internet depends on how much the students want to use it.

8.4 EVIDENCE FROM ONLINE CHAT

Students in the Year 11 and 12 physics classes (2002) had the option of participating in online chat sessions that were available to them once a week after school. The session ran for an hour and students were allocated chat time of approximately 20 minutes each. Each student formed a part of a group comprised of four to five students. The groups were created on the basis of student's abilities.

Student comments on this feature of web-based learning were very positive and these have been quoted in the discussions throughout this chapter. A part of the chat session is reproduced in Table 8.1. In the five minutes segment (from 16:44 to 16:50) shown in the table below, there were 15 interactions within the group comprising of the teacher and four students. Through these interactions, three out of the four students successfully answered a question which could be considered to be of moderate difficulty.

Table 8.1

Part of a Chat Session (All student names have been replaced by fictitious names).

Date/time	Discussion
Aug 13 16:44:	TEACHER> Here is today's question - A beam of electrons with energy 4.0eV is directed towards sodium vapour in an evacuated chamber. Electrons with energies of 4.0eV, 1.9eV and 0.8eV are detected on the sensor. What conclusions can you draw from this observation?
Aug 13 16:46:	Jones> the 4eV electron goes straight through as it has not collided with any other particle as it has not lost any energy. The electron with 1.9eV left lost 2.1eV worth of energy as it collided with particles and caused another electron to gain an energy level. The electron with 0.8eV left lost 3.2eV of energy as it collided with another particle, causing an electron to go up to level 2. Hence, it can be concluded that in a Sodium Atom, the ground state has 0eV, the second level requires 2.1eV of energy and the third level requires 3.2eV of energy.
Aug 13 16:47:	Einstein> The electrons that came out with 1.9 eV hit one of the Na atoms and gave it 2.1 eV to raise it to an excited state. To raise it to the next level requires 3.2 eV of energy. Hence, it can be concluded that there will be fluctuations every 2.1 V in the I - V graph. It can be drawn from the statement that the electrons that came out with 4 eV went straight through without colliding with any Na atoms. The ones that went through and hit one Na electron lost 2.1 eV, and the other electrons that hit two other Na atoms would have lost 3.2 eV.
Aug 13 16:47:	Danzel> The 1st level is at 0eV, the 2nd is at 2.1eV and the third at 3.2eV. This explains the loss of energy for the 1.9 and 0.8eV electrons because it was used to go to the next level. The 4eV electron must have passed through without colliding and therefore didn't lose energy
Aug 13 16:47:	Charlie> the first energy level is at 2.1eV and the 2nd at 3.2eV
Aug 13 16:47:	Charlie> you just beat me to it!!!
Aug 13 16:47:	TEACHER> Jones I have to give you 3/3
Aug 13 16:48:	Jones> thankyou
Aug 13 16:48:	TEACHER> Einstein – 3/3
Aug 13 16:49:	Charlie> Oh, I consider ground level as level 0
Aug 13 16:49:	Einstein> Excellent, Jones.
Aug 13 16:49:	TEACHER> Danzel - 3/3
Aug 13 16:49:	TEACHER> Yes, Charlie
Aug 13 16:49:	Jones> excellent Einstein and Danzel
Aug 13 16:50:	TEACHER> OK boys here is the next part of the question - Another beam of electrons with the same energy is directed towards hydrogen vapour. Only

electrons with energies of 4.0eV are detected on the sensor. Why?

The discussion in the table above reflects the quality of the interaction that can occur through web-based learning. All participants (including the teacher) were on task and thinking on their feet. Students had the convenience of interacting from the comfort of their homes. They interacted, in the process enhanced their understanding of the subject matter, and received good scaffolding. With a group of motivated learners, the right questions often led to a highly productive and efficient discussion. According Greenough (as cited in Jensen, 1999), a better brain can be developed through two initiatives. Firstly, the learning should be "challenging with new information and experiences" and secondly, "there must be some way to learn from experience through interactive feedback" (p. 32). The chat option as demonstrated in this instance is one of the ways such outcomes can be achieved.

8.5 STUDENTS PERCEPTIONS OF THE LEARNING ENVIRONMENT – THE FINDINGS OVERALL

Chapter Three of this thesis reviewed various aspects of technology in learning. In the development of *Getsmart*, numerous issues raised in Chapter Three were taken into consideration. The negative perceptions of some commentators (e.g., Oppenheimer, 1997) were addressed by designing a website on sound principles of electronic cognitive apprenticeship (Bonk & Kim, 1998; Collins, Brown, & Newman, 1989). The observation made by Janicki and Liegle (2001, p. 58) that according to many researchers "the current web-based educational tutorials are poor in educational content" was also an important consideration.

One of the key aspects of this research was to establish the perceptions of students of this innovative approach. Quantitative results presented in Chapter Seven and qualitative results in this chapter suggest that students have positive perceptions of a web-based learning environment. Roblyer (1999, p. 158) referred to the delivery truck debate initiated by Clark who said that computer based instruction was merely like, "vehicles that deliver instruction but do not influence student achievement any more than the truck that delivers our groceries causes changes in our nutrition."

What mattered to student learning was the way the content was being delivered rather than the method of delivery. The evidence above confirms this analogy by Clark. In this instance, it was the design of *Getsmart* which depended on reliable technology that led to positive perceptions amongst students of their learning environment. It supports a common view expressed by numerous researchers that technology alone does not make a difference: how it is used makes the difference (eg. Downes, 2004; Spender, 2004; Stager, 2004).

In Chapter Two on learning environments, findings of numerous studies were highlighted. Some of the issues raised in these studies have been explored further in this study. Whenever an innovative practice is introduced in traditional teaching environments the change in student perceptions as a result of this can vary. For instance, in separate studies, Hofstein, Kesner, and Ben-Zvi (1999) and Hofstein, Nahum, and Shore (2001) reported positive perceptions when the normal routine in chemistry classrooms changed. Likewise when technology is introduced in classrooms the effects are dependent on the quality of the learning on which the learning materials are based. Hartwell, Gunter, Montgomery, Shelton, and West (2001), found no difference in student perceptions when technology was integrated in primary maths and science classrooms. Elen and Clarebout (2001) on the other hand found that an "ill-structured innovation" can impact negatively on students' perceptions. Thus, just because students are logged onto the Internet does not necessarily produce desirable outcomes.

As discussed in Chapter Seven, the results of this study have shown that students have positive perceptions across three of the four scales of the WEBLEI and there was moderate agreement with the Interaction scale. These values compared well with Chang and Fisher's (1998) findings in which WEBLEI was administered to students in a wholly online tertiary environment. Qualitative data supported the results produced by the WEBLEI.

Numerous studies referred to in this research provide additional support for student responses and the WEBLEI scales. For instance, Jensen (1998), gave three reasons why prolonged periods of concentration were counter productive. He also pointed out that the brain needed time to process information (Jensen, 1998). It is probably for this reason that many students indicated that an alternative to the classroom was one good feature of a blended learning environment. The WEBLEI's Access scale dealt with the characteristics of the learning environment such as access, autonomy, and convenience. Students' qualitative responses overwhelmingly suggested that this was important to them because the pace of learning gave them an opportunity to create rules of learning themselves rather than being dictated to by the teacher. They were also not forced to concentrate for prolonged periods. Tomlinson (1993) supported such an argument when he pointed out that the brain learnt best when it can understand by "making its own sense out of information rather than when information is imposed on it" (p. 18).

The relatively high agreement to the items of the Response scale suggests that students' felt very good about their web-based learning environments. The qualitative data provided supportive evidence for this result. Researchers such as Vygotsky, Bess, and Jensen believed that the brain learnt best when the context provided a moderate challenge (Tomlinson, 1993). Tomlinson, also pointed out that if the task was too difficult, the learners shift down into a self-protection mode. On the other hand, if the task was too simple, the learners thinking and problem solving ability diminished and he or she drifted into a relaxation mode. From the data presented so far, the approach to web-based learning in *Getsmart* must have been pitched at the right level otherwise the perceptions would not have been so positive.

The items on the Results scale were very well received by students. This scale gives an indication of whether the learners had accomplished any learning objectives through this learning environment (Chang & Fisher, 1998). The WEBLEI and qualitative data suggested that students did benefit from their learning environments. For these results to have been achieved, the design and content of the website must have addressed the needs of most learners. Gardner pointed out that (Siegel & Shaughnessy, 1994, p. 564):

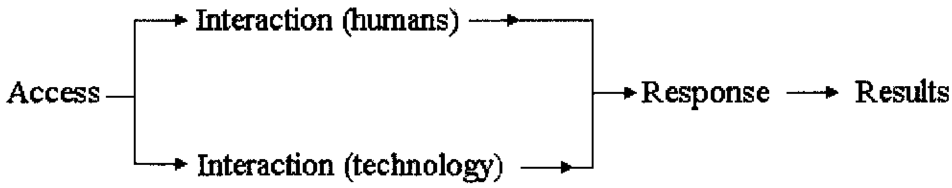
> The biggest mistake of past centuries in teaching has been to treat all children as if they were variants of the same individual, and thus to feel justified in teaching them the same subjects in the same ways.

Sarason (1993) believed that there was an overwhelming desire amongst learners to engage in learning which utilised different teaching methods. He also pointed out that present one-size fits all delivery system had failed the learners. In this research, a blended learning environment appears to have met the needs of a variety of learners. It also generated positive perceptions amongst students in different year levels and subjects.

The findings of this research also suggest that the items on the Interaction scale of the WEBLEI were inadequate in measuring the interaction between learners and technology. Students appear to have achieved more through their interaction with the technology itself by using applets, simulations, online tests, and online experiments. Qualitative data and teacher observations supported this view. In the initial design of the WEBLEI, Chang and Fisher (1998) proposed the following connection between the scales:

Scale 1 (Access) → Scale 2 (Interaction) → Scale 3 (Response) → Scale 4 (Results)

In this study, it appears that the Interaction scale was not as significantly interconnected as the other three. When Chang and Fisher (2003) administered the WEBLEI to university students, they reported values of 3.96, 3.55, 3.37, and 3.72 for Access, Interaction, Response and Result scales, respectively. In their study, the Response scale was rated the lowest. In this study, the Interaction scale was rated the lowest in many cases. While the characteristics of the items in the Interaction scale are important qualities of online learning, in this case it appears that there was significant interaction between students and technology. It is probably this interaction (rather than interaction between learners and educators) which led to a significantly higher mean for the Results scale. Otherwise, given the rationale of the design of the WEBLEI, these results may not have been obtained. Hence, another scale should most probably be added to the existing WEBLEI design with items that specifically measure the interaction of learners with technology in an online learning environment. The following relationship would then exist between the scales:



As discussed, the WEBLEI was initially designed for students at universities in off-campus environments where the interaction between learners and educators via the Internet was essential. In a blended learning, high school environment, learners are probably looking for an interactive learning environment with technology. They are looking for an opportunity to be away from the classroom momentarily and from human beings. While emails are productive for the ideal student who reviews his or her work on a daily basis, identifies problems, and forwards queries electronically to his or her teacher, very few students probably fall in this category. High schools are probably still a few years away from producing a learning culture where learners have the confidence to conduct their learning in this manner. For many, asking the teacher questions face to face in class is probably viewed as a more feasible and preferred option.

In most instances across the entire sample, suggestions made on improving the website were related to interactive activities, links, graphics and aesthetics of the site. The Year 12 physics sample (2003), for instance considered these features to be important (in descending order): tests, clear and concise notes (with examples and exercises), revision exercises, clear graphics (pictures and diagrams), links to other sites, online experiments and the layout of the pages. The features mentioned in this case were important to the students; hence, based on qualitative data such as this, the WEBLEI probably needs another scale to measure the interaction between participants and technology. Whitlock (2001, p. 188) listed the top ten features of a well designed online course: "clearly specified objectives, attractive presentation, clear signposting, ease of use, appropriate language, modular structure, variety of questions and problems, feedback on progress, testing and logical sequence."

Brain research and educational psychology theories should also be considered in designing items for the new scale. Research by Salomon, Globerson, & Guterman (1989) and Salomon, Perkins, and Globerson (1991) on computer designed reading activities led to improved outcomes in not only reading but also essay writing skills. They found that the computer in their research acted as a "more capable peer" by enabling "mindful learners to engage in cognitive processes of a higher order than the ones they would display" (Salomon, Perkins, Globerson; 1991, p. 5). However, they also pointed out that for learners to achieve the desired outcomes, the technology must provide explicit humanlike guidance.

McInerney and McInerney (2002) pointed out that while the theories of Piaget and Vygotsky varied, they both believed in the active involvement of children in learning. Apart from emphasizing the importance of peer interactions they also detailed the need to create learning experiences that were relevant to "real world" experiences. McInerney and McInerney (2002) also explained the need for mentoring practices in a social framework in which a learner's intelligence developed. They also believed that such a development should occur in an authentic environment and the learning should occur in an interdisciplinary approach.

Perhaps the new WEBLEI scale should measure the extent to which the website provided humanlike guidance which enabled learners to interact with quality real world or simulated experiences. It should measure the extent to which a website "talks" to the user and gives directions in the same way a teacher would. The following items are proposed for the new scale of the WEBLEI on the basis of the discussion of the last few paragraphs:

1. I can work out where the links are on this website.
2. The links on this website work well.
3. I can access real life examples using this website.
4. I can access simulations using this website.
5. This website has a good variety of virtual interactive options.
6. Online tests give me an idea of my performance.
7. I can work out which questions where I went wrong.
8. I can track my performance (test and login details) on this website.

8.6 CHAPTER SUMMARY

Student responses from the WEBLEI and qualitative methods suggest that students have positive perceptions of this approach to learning. The parents, education authorities, and the public as a whole want more than positive perceptions. Schrage of the Los Angeles Times (as cited in Dierker, 1995) probably summed up the views of those with a stake in education and the expectations they had of such innovations. Schrage believed that computers were irrelevant to the quality of education. He also pointed out that any school board that used computer technology without insisting on explicit guarantees for improved student performance deserved to be "impeached, voted out of office or sued for malpractice" (p. 229).

The chapters that follow address the concerns raised by Schrage. Specifically, Chapter 9 explores the extent to which web-based learning impacted on student attitudes to science and physics. Chapters 10, 11, and 12 presents evidence on how the website impacted on students' performance in these subjects.

CHAPTER 9

THE IMPACT OF A WEB-BASED LEARNING ENVIRONMENT ON STUDENTS' ATTITUDES TO PHYSICS AND SCIENCE

9.1 INTRODUCTION

Jensen (1998) believed that the brain was self-referencing and it decided what to do based on previous experience. Such a theory has significant relevance to learning environments. Learner's positive perceptions of their learning environments can have significant implications on how they learn and achieve in their learning tasks. This research was essentially a study of these connections. The study explored the inter-connection between students' perceptions of an innovative teaching approach and how it impacted on their attitude and performance in science and physics. If an innovation is well received by the students, then they will have positive perceptions of their learning environments. Chapters Seven and Eight established that students who participated in this study found the design of *Getsmart* and its implementation in a blended learning environment to have met their needs. Qualitative and quantitative data demonstrated that students' had positive perceptions of their web-based learning environment.

Not all reforms in the curriculum improved attitudes towards subjects. In many countries, even with concerted efforts aimed in this direction, student attitudes to subjects did not change. For instance, Ebenezer and Zoller (1993) found no changes in the attitudes of Grade 10 science students in Canada as a result of changes to the curriculum. Did web-based learning change students' attitudes in this study? This chapter explores the impact of *Getsmart* by taking it one-step further. If students have a positive perception of this learning environment, then did this reflect in their attitudes to science and physics.

In this chapter, section 9.2 discusses students' attitudes to science and physics by examining the data collected quantitatively. Similarly, qualitative data is also presented and discussed (9.3). In section 9.4, quantitative data gathered online and students' use of the website is presented. This data supports Koballa's (1988) belief that there was a relationship between behaviour and attitude. The last section (9.4) summarises the findings of this chapter.

9.2 QUANTITATIVE EVIDENCE

A review of science education in Australian Schools was presented in section 4.2.1. Some of the points raised in 4.2.1 probably explain student attitudes to science and physics in modern classrooms. Goodrum, Hackling, and Rennie (2001) pointed out that the actual picture of science was disappointing and quality of teaching ranged from brilliant to appalling. Researchers in other countries mirrored various aspects of their findings and suggestions (eg. Gibbs & Fox, 1999; Millar & Osborne, 1998). Millar and Osborne (1998, p. 2005) suggested that the science taught in modern classrooms focussed on discrete ideas which failed to sustain and develop the interest of many students about the natural world. They also suggested that a variety of teaching methods and approaches that had a potential to influence the pace of learning should be incorporated in classrooms (Millar & Osborne, 1998). Such initiatives should be designed so that they enable teachers to cater for the needs and interests of the learners.

In their study, Goodrum, Hackling, and Rennie (2001) sought the views of teachers and students and others who had an interest in science education. Their findings were derived through qualitative and quantitative methods and some of their results could be used to explain student's attitudes to science and physics. Their quantitative data showed that:

- 61% of the students copied notes given to them by the teacher *nearly every lesson* (p.118).
- 59% of the students *never* had a chance to choose topics which they wanted to investigate (p.118).
- 47% of the sample got a chance to think what they doing either *once a term* or *never*. (p.118)
- 87% of the sample used computers *once a term* or *never* (p.121).
- 81% of the sample looked for information on the Internet either *once a term* or *never* (p.121).

A web-based learning approach in a blended learning environment was used in this study. It was hoped that such an innovative approach, coupled with traditional classroom routines, would produce variety and flexibility in lessons through the use of technology. Consequently, if this blended learning approach worked for students, then it had the potential to address some of the concerns highlighted in Goodrum, Hackling, and Rennie's (2001) report. These issues were considered important because they seemed to involve a large number of students. Consequently, they have the potential to impact on students' attitudes to science.

Some of the other issues raised by Goodrum, Hackling, and Rennie's (2001) report formed the basis of an *Attitudes to Science* survey in this study. This survey consisted of seven items and was administered to students before and after they had participated in the web-based approach. Table 9.1 shows these seven statements and how they relate to the evidence provided by Goodrum, Hackling, and Rennie's (2001) report.

A five-point Likert response format was used in this survey for each of the seven items. The responses were scored as follows – *Strongly Agree* (5), *Agree* (4), *Neither Agree nor Disagree* (3), *Disagree* (2), *and Strongly Disagree* (1). Items 2, 4 and were worded in reverse and scored accordingly.

The survey was administered to students in five classes in 2002 (four year 10 science and one physics class). The Cronbach alpha coefficient for the attitude to science scale was found to be 0.85 (N = 226). The closer the alpha coefficient is to 1.0, the greater the internal consistency of the items in the scale. George and Mallery (2003) believed that an alpha of 0.8 to 0.9 was good which suggested that in this case it was a positive reflection on the seven items of this scale.

All surveys were analysed collectively as one sample. The five groups chosen for this survey were a good representation of the whole sample because their means for the Access (M = 3.94, SD = 0.62), Interaction (M = 3.65, SD = 0.65), Response (M = 3.82, SD = 0.57), and Results (M = 3.96, SD = 0.61) scales of the WEBLEI were comparable. The whole sample had means of 4.02 (SD = 0.58), 3.57 (SD = 0.66), 3.76 (SD = 0.67), and 3.98 (SD = 0.58) for Access, Interaction, Response, and Results scales respectively.

Table 9.2

Results of the Attitude to Science Survey Administered to Students at the Commencement and Conclusion of the Research.

Attitude to Science survey	Mean	Standard Deviation	Valid Cases
Attitude survey administered at the start of the research (b)	2.93	0.93	83
Attitude survey administered at the completion of the research (a)	3.22	0.85	83
Difference in means (a-b)	0.29**		
Effect size	0.33		

** $p<0.01$

Table 9.2 shows the results of the survey which was administered to students before (and after) they engaged in web-based learning. In both instances, the means were close to three, which suggested that overall the students neither agreed nor disagreed with the items. However, the mean obtained after the students had participated in web-based learning was higher and a paired sample t-test showed that this difference was statistically significant ($t(82) = 5.54$ at $p<0.01$). The difference in the means had an effect size of 0.33. Cohen (1988) interpreted an effect size of 0.2 as small and 0.5 as medium. Hence, in this instance web-based learning had a small to medium effect on student's attitudes to science. The standard deviation also decreased which suggests that there was a fall in the spread of student responses.

The two sets of attitude to science scores were strongly correlated, $r(81) = 0.86$, $p<0.01$. In this case, the significance level was very small which suggests that the correlation was significant and the two variables were linearly related. Figure 9.1 shows a plot of the two sets of scores.

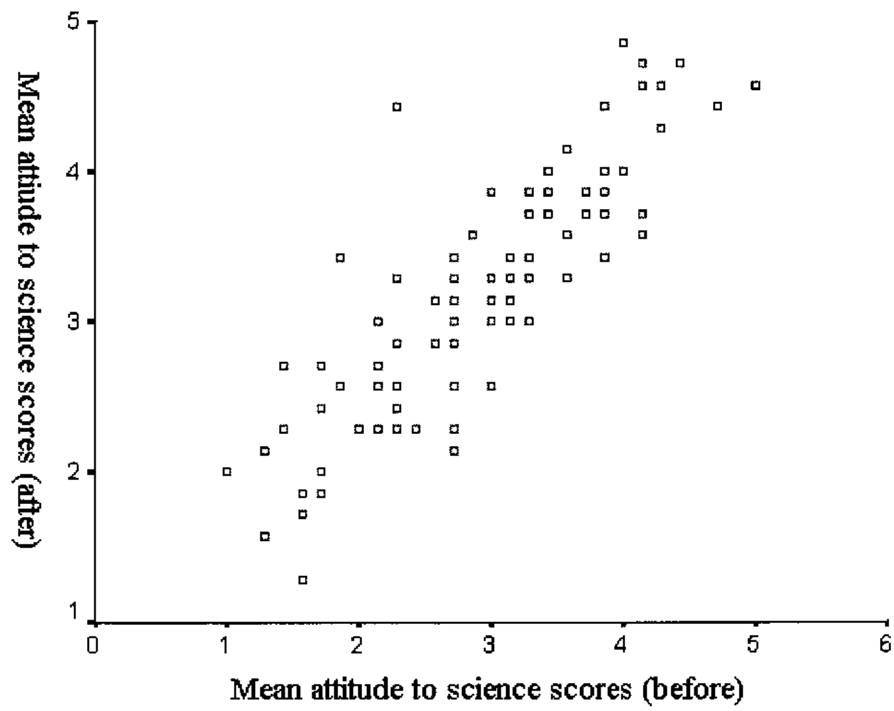


Figure 9.1. Attitude to science scores; before and after the students engaged in web-based learning.

The association between the four WEBLEI scales and the Attitudes to Science Scale after they had they had completed their term's work in the blended environment was investigated. The results of this analysis are presented in Table 9.3.

Table 9.3

Associations between WEBLEI scales and the Attitude to Science Scale in Terms of Simple Correlation (r) and the Standardized Regression Coefficients (beta).

WEBLEI Scales	Sample size	Attitude to Science *R*	*beta*
Access	84	0.13	-0.14
Interaction	81	0.22*	0.22
Response	76	0.24*	-0.04
Results	84	0.26*	0.23
Multiple R Correlation		0.38	
R^2		0.15	

*p<0.05

The simple correlation(r) reported in Table 9.3 indicated that three of the four scales were significantly related to the Attitude to Science scale. The Interaction scale of the WEBLEI gives an indication of the quality of the interaction between the virtual learning environment and the learners. The Response scale of the WEBLEI gives an idea of how students felt about a web-based learning experience. The Results scale gives an idea of whether the students felt that they had accomplished some learning objectives through this learning environment. In this case, the means of the interaction, response, and results scales were all positively and significantly correlated ($p<0.05$) with their attitudes towards their subject scale.

The quantitative analysis discussed above suggests that web-based learning did produce a change in students' attitudes to science. This was demonstrated by a higher mean of students' scores to their Attitude to Science (after) scale when compared to their scores for this scale before they engaged in web-based learning. There was also a positive correlation between the four scales of the WEBLEI and the attitudinal scale, which suggests that positive perceptions of a web-based learning environment probably led to improved attitudes to science.

9.3 QUALITATIVE EVIDENCE

Qualitative data were also gathered from students to see the extent to which their responses agreed or disagreed with the findings of the Attitudes to Science survey. During the course of the research, 292 written responses were received from students in 15 science and physics classes. A total of 224 responses were submitted in 2002 and another 78 in 2003. There were two specific questions asked to gauge students' attitude to science. In the first question, students were asked the following question:

Do you think that the Internet lessons made science (or physics) more interesting?

The rationale of the seven items of the Attitude to Science scale was built on students' interest to science. Instead of asking specific questions, open ended questions were used in the hope that a variety of responses would be obtained. The second question was:

Would you like to have Internet lessons in science (or physics) next semester?

The logic of this question was that if students had gained something from this initiative, then they were more likely to want to engage with it in the future. Responses to these questions provided further evidence of the association between web-based lessons and their attitudes towards science and physics. All groups were given these questions (except Year 12's who were in their graduating semester, so the second question did not apply to them). The responses are discussed on a group by group basis.

9.3.1 Group I: Year 10 Science (2002)

Almost 87% of the Year 10 sample (N = 214) in 2002 answered "yes" to the question, "Do you think that Internet lessons made science more interesting?" In their written responses, students indicated that they found web-based learning more interesting because it added variety to their lessons. Some of the reasons given were:

I am sick of lectures...computers add variety to a subject

You are not in the classroom just staring at the blackboard. It is interesting to go to the site.

You can do different things and view things that you did not know.

A good break from the classroom where other members of the class can disturb you.

You are not sitting in a cold dull science room.

In numerous other responses, students stated that since the approach was interesting it made learning easier and more effective:

We have a worksheet to complete so everyone does actually work and later when we do not understand, we can go back to the sheets.

If you get bad marks on the online test, it makes you want to learn the subject more.

Web-based learning makes me think clearer.

You learn without feeling you are learning. Easy to absorb and remember.

I can see visuals for what the teacher is trying to teach.

We can do it ourselves. They have examples we can use and I think it's great.

Some students believed that this new way to learn was interesting because it had pictures, diagrams, and examples. They also felt that actively participating in activities such as launching rockets and answering tests increased the interaction between the Internet and them. This also appeared to minimize boredom. Not having to listen in class and write notes also made science interesting. They felt that these lessons were a break from class that motivated them to do the work.

Better than sitting in the classroom and have to listening the whole time...in one spot.

Did something besides sitting at our desks in the classroom.

We were not sitting in a classroom writing boring notes.

Because classes are not interesting...when teachers are talking people fall asleep.

Yes, it is a change from students listening to a teacher and students writing down notes all lesson.

Numerous responses suggested that it was another way to learn and which was fun. For some students', the freedom to work independently was important:

We can do it ourselves, they have examples we can use, and I think it is great.

Various other individual comments were also positive. These included comments like: *set-up was very clever…links are good too; the website is educational* and *it is easier to learn something if you are interested in it.* In one response, a student stated that because of the web-based approach was interesting and different; students looked forward to the lessons. The students who did not find web-learning interesting were those who did not find anything useful in this approach. Many in this group could not give a specific reason for their answer. One student wrote: *science is science and it always bores me.* Another believed that he or she would *rather listen to some teacher mumbling on and on about science.* It was also notable that the number of students who did not find this approach to learning interesting was comparable across the nine classes. There were two to four students per class, which suggested that the teacher's role in this respect was minimal. The relative proportion of boys to girls who did not believe that web-based learning made science more interesting was almost one to one. This was confirmed with the WEBLEI where it was also found that both boys and girls in year 10 science perceived the learning environment similarly (see section 7.3.4). Hence, if they perceived the environment similarly, then their attitudes to the subject were similar as well.

In response to the question, "Would you like to have Internet lessons in science next semester?" 85% of the population responded yes, 10% said no and the remaining 5% did not state an opinion. Students felt that this mode of learning was less stressful and it was better than a normal way of teaching. Another wanted the web-based learning approach because it had improved his learning. Other students felt that they also learnt and understood more and this was one of the reasons for wanting more of this approach. Examples of student responses were:

Yes, I have realised that it has helped me learn the work a lot better; it really guides me through the work well.

I think the tests helped…I had to read and understand the information instead of just tuning out and daydreaming in class.

Learning from different sources makes it more interesting...I believe it must be an extension of class work.

There is less writing to do and you can still learn the same stuff.
The rocket was "rad"...being on the net is awesome...it's better learning off the net.

The interaction factor was also important. One student highlighted the need for it to enable students to learn. Another wanted web-based learning the following semester because she felt that working from a textbook was *really, really boring* and if they sat *in class the whole time, science got boring.* Consequently, the student suggested that they stopped enjoying the subject. In another response, it was felt that it was *a better way to learn instead of listening to your teacher blabber on.* Some students believed that web-based learning was *fun as well as learning*; *it was enjoyable*; *and it was good to be able to do tests at home.* Another pointed out that *Getsmart made science more fun and interesting* than how science was really perceived and, consequently, the web-based lessons and science were *something to look forward to.* These responses clearly indicated that if students enjoyed the lessons then it helped them learn more because it gave them the feeling that they were *doing a good job.*

One response outlined that many students could be helped by mixing normal science work and computer work. Such an approach enabled them to work at their own pace because they could look up things that they did not understand. One stated that *I work at my own pace and I do not have to be left behind while writing.* For students who did not want the web-based learning the following semester (10% of the population), there were two main reasons: one was that they felt that it cost them money (e.g., *Web lessons take my Internet money*) and another was that they were better off in the classroom (eg. *rather listen to some teacher mumbling on and on about science*).

9.3.2 Group II: Year 11 Physics (2002)

These students were asked if web-based learning made physics more interesting. More than 70% of the group felt that Internet lessons did. Unlike, the previous group, none of the students believed that this was because normal physics lessons were boring. One student wrote that *physics was already interesting.* Student responses suggested that *Getsmart* created enhanced learning opportunities and provided scaffolding. Consequently, it led to increased interest in physics as reflected in these responses:

The webpages are incredibly helpful…it gives me a chance to learn what I need instead of going over what I am already comfortable with.

The website gave you another way of looking at things.

You are in control of the lesson. You determine…how fast you learn…decide what the important facts are.

…animated diagrams which I can understand more

The few who did not think that it made the subject more interesting explained their answers as follows:

No, it is like a virtual textbook which is easier to understand…but does not make it more interesting.

I do not think it made the subject any more interesting as such, just more helpful. However, for the same reason, I prefer to look at a computer screen than a textbook.

While not all students found web-based learning compelling, they all wanted this approach to be incorporated in physics teaching the following semester. The fact that the website enhanced their understanding in the subject explained their responses. Explanations included reasons such as web-based learning gave *everyone a chance to learn individually* and it not only motivated students but also with the quizzes, brought clarity to the work done in class. Other reasons included:

I believe it will help me improve my grades in physics.

Yes, I would indeed, because I do not like working in a vacuum.

I liked the booklets (worksheets) that were handed out as summaries rather than the teacher's writing on the board.

Yes, I think it helps answer many questions when I am not at school. It provides a variety of questions for me to do.

9.3.3 Group III: Year 12 Physics (2002)

It was interesting that the relative proportion of students who believed that the web-lessons made physics more interesting was almost the same in years 11 and 12 physics classes (more than two-thirds of the sample). Students found the approach interesting because:

The chat worked well, because I had to actually keep up with what was going on in class. In that, it kept me more involved and interested.

New approach...The idea of after school chat lessons with a teacher is enough to attract the laziest of students.

It is easier to learn when you see diagrams and pictures.

The students who did not believe that web-based learning enhanced their interest in the subject gave reasons such as:

It did not make it more interesting, but rather gave it a focus. Interest in science depends on the individual, but can be made interesting in a more practical and animated environment.

Maybe not interesting, but it did make the work a lot easier to understand.

9.3.4 Group IV: 10 Advanced Science

As with previous groups, the students were also asked if web-based learning made science more interesting and 84% of the students in this group wrote yes, 12% wrote no, and a further 4% were in the maybe category. A significant number of these respondents thought that this was due to the active participation of students through hyperlinks, video clips, tests, and online experiments. The quality of the graphics and diagrams on the pages also sustained student interest. Being away from the classroom was another reason that increased student's interest in the subject. Some students expressed their reasons as follows:

Great graphics and colours interest you to look or go on.

It is better than sitting in a classroom, bored. You are actually, actively doing something.

Because it was something different and fun to do...better than writing all the time.

No need to hear teacher's voices again (unless you need help) and after everything has been read, it goes straight to your brain.

Yes, because it allowed girls to move away from certain bigoted boys, thus allowing us to learn without having to hear their very boring life story.

It was cool to get your test results instantly...

Fun diagrams...sometimes explained something that I didn't understand.

The small group of students who did not think that it made science more interesting gave reasons such as they liked listening and learning and they preferred to have the teacher teaching the course. These reasons suggest that a small proportion of students probably preferred a different learning style from the others.

9.4 QUANTITATIVE EVIDENCE – ONLINE DATA

In this research, login data were gathered together with students' responses to specific questions which were presented to them online. Students' use of the website was a good indication of their attitudes towards *Getsmart* as a learning tool. Obviously, if using it was not seen as a productive exercise, then students were less likely to use it especially in their own time. Koballa (1988) pointed out that there was a relationship between behaviour and attitude.

In the first year (2002) of this research, 11 classes participated. Unfortunately, the quality of the data collected online was unreliable, because some students learnt how to by-pass the login screens. In 2003, this problem was rectified and students could not login unless they had the correct username and password. A total of 104 students from four classes (two year 12 physics and two year 10 advanced science classes) used *Getsmart* on a weekly basis. There was another year 10 advanced science class (N = 30) which used the website on an *ad-hoc* basis but did not participate fully in this research. Hence, there were a total of 134 students in these classes.

Login data suggested that 87% (N = 116) of the group in 2003 logged in at least once on the website. On average, students logged in 14 times. The number of logins per student ranged from 1 to 106 over a seven-month period. Of the 1,683 student logins over this period, 62% of these occurred in students' own time outside scheduled lessons (e.g., lunch breaks, after school in the afternoons, evenings, week-ends and public holidays). The time at which students logged in during the day was also informative. These times are plotted in Figure 9.2.

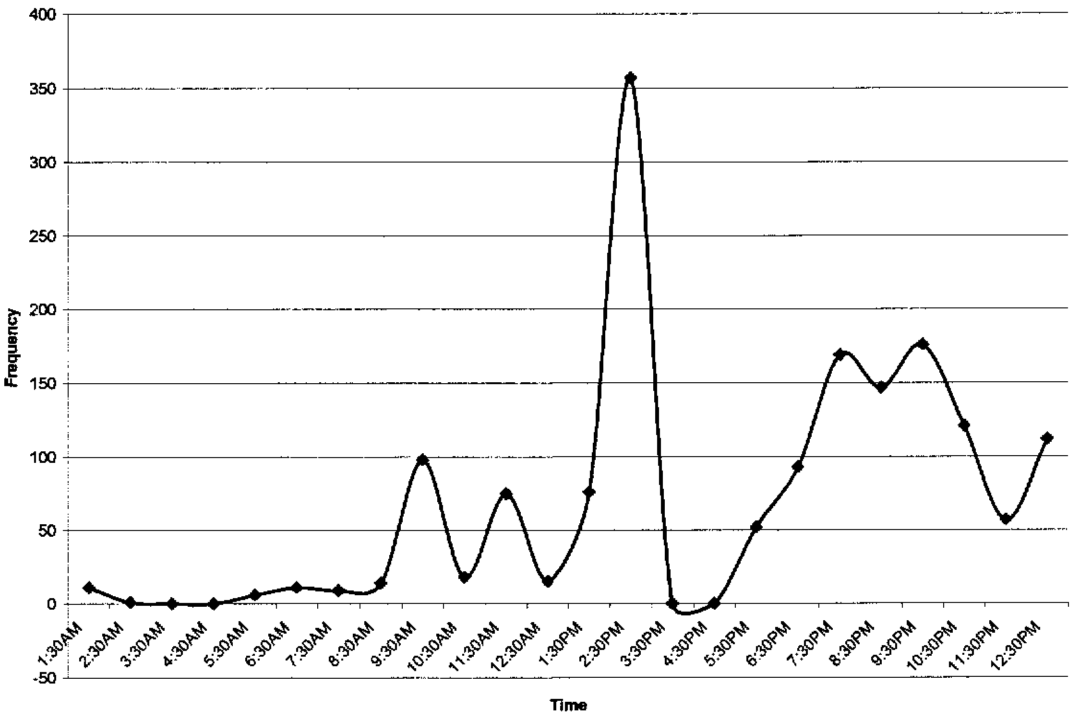


Figure 9.2. Frequency of website login over 24 hour periods from April to October 2003.

The peak observed at 2.30 pm (Figure 9.2) was largely due to the fact the majority of the students were timetabled for Internet lessons on school days. However, students' login frequencies after school were most significant. Most students actively used the website after 4.30 pm and until 11.30 pm. It was also interesting to note that the website had no users between the hours of 3.30 and 4.30 in the afternoon and also in the early hours of the morning (2.30 to 4.30 am). For 20 hours a day, the website had at least one or more users who had logged in. A graph as also plotted to show the frequency of website use on a monthly basis. This is shown in Figure 9.3.

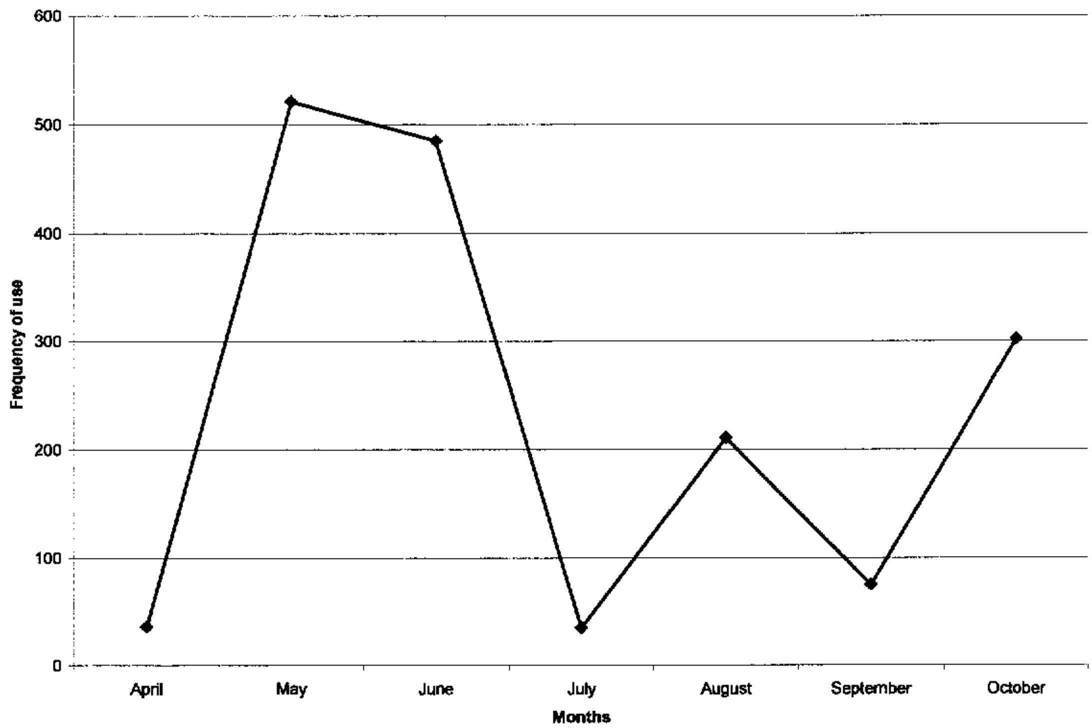


Figure 9.3. Frequency of website login over 24 hour periods from April to October 2003.

The year 10 advanced course was taught in a blended mode in term two of 2003 (April – June). Consequently, the website was used extensively in May and June by 104 students enrolled in this subject (Figure 9.3). From July to September, 30 year 12 physics students were taught the subject in this environment. What is noteworthy is that the students continued to use the website in October when there were no courses designed for this mode. However, the students who used the website were Year 10 Advanced Science students who previously had used the website. They used the web-designed lessons for their other subjects in term 4. This behaviour of the students was a reflection of their belief that the website was a valuable part of their learning. One student explained her reason for revisiting the website regularly as follows:

There were many reasons why I used your computer program even after the science course. After the advanced science course, I did biology and chemistry. Getsmart helped me understand what I had been taught in class much better. The pictures were also interesting as sometimes I find that too much reading turns me off from my studies. For example, for biology, I used the website to understand the concept of genetics further.

Year 10 Advanced Science student (female)

At the end of each lesson, students had the option of rating their web-based lessons as either *excellent, very good, average, needs improvement* or *a waste of time.* This was done online and their responses were written to the database. Figure 9.4 shows student responses from April to October (2003).

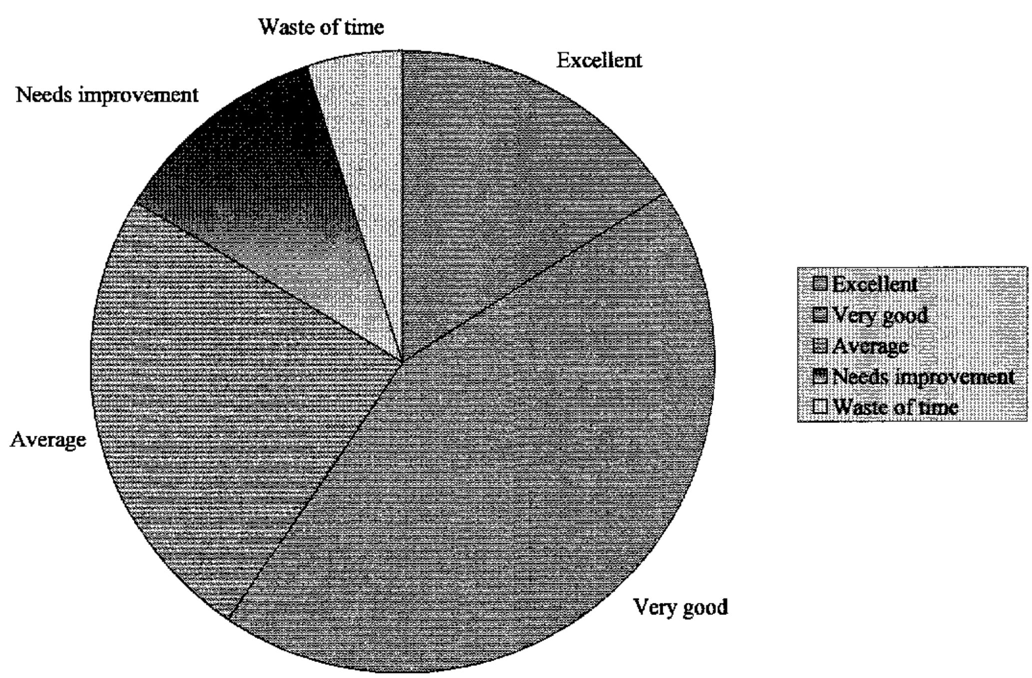


Figure 9.4. Students' ratings of the web-based lessons.

As shown in Figure 9.4, more than half (60%) of online survey respondents (N = 418) rated the lessons as either very good or excellent. One quarter of the group believed that the lessons were average and one-tenth of this sample thought that the lessons needed improvement. Only five-percent felt that these lessons were a waste of time which suggests that for the majority of the students, such an approach was perceived to be valuable in terms of their learning.

9.3 CHAPTER SUMMARY

In this chapter, qualitative and quantitative data both suggested that the web-based learning experience did improve students' attitudes towards their subjects. The Attitude to Science scale showed that students' attitudes to science (and physics) improved after immersion in a blended learning environment. Between 70-80% of the qualitative responses supported the findings of the quantitative survey. There was also an association between the perceptions of the learning environment and attitude to science (and physics). Student behaviour in terms of the use of the website and their assessment of the lessons through the online survey further provided evidence that students had positive attitudes towards such an environment.

One student wrote *it's easier to learn something if you are interested in it.* The next two chapters explores this connection by analysing the extent to which a blended web-based approach influenced learning outcomes in physics and science.

CHAPTER 10

THE IMPACT OF A WEB-BASED LEARNING ENVIRONMENT ON ACADEMIC ACHIEVEMENT IN SENIOR PHYSICS

10.1 INTRODUCTION

At school level, the impact of innovative teaching methods is often viewed in terms of how it affects learning outcomes. In many cases, for students, administrators, and parents, an innovation is successful if it increases marks. In their report on science education in Australia, Goodrum, Hackling, and Rennie (2001) reported that on average, tests represented 55% of the weighting of the assessments and students had to remember many facts to succeed in them. In senior physics, tests represented more than 90% of the assessment.

When an innovation fails to meet student expectations, panic may set in because students develop a fear that the innovation may jeopardize their chances of a getting a good grade. For instance, when case-based learning was introduced in an Introductory Chemistry course at Duke University, students expressed their anger "by writing expletives on their papers and filling in random answers" (Herreid 2003, p. 8). Consequently, the assessment was worthless. John Simon (the chairperson of the chemistry department) explained reasons for introducing this approach and interpreted student resistance as follows (as cited in Zurer, 2002, p.32):

> Why should students today be learning the same things I learned in 1975? ...The idea was to talk about issues of current importance and themes from current chemical research, relating them to the underlying principles...We wanted to make the lectures enriching. Going in and just regurgitating what's in the text makes no sense. They were only concerned about grades...They have never been challenged...They need to learn how to learn in different environments. Instead, they are really angry that we have made them work really hard.

In Chapters Seven and Eight it was shown that there was a possible connection between the use of *Getsmart* in a blended web-based learning approach and students' perceptions towards such an environment. In Chapter Nine, a similar relationship was shown between such an environment and students' attitudes to science and physics. It is believed that positive attitudes to science do influence learning outcomes (International Assessment of Educational Progress, 1992). Was this observed in this study as well? This chapter together with Chapter 11 explores the extent to which web-based learning and *Getsmart* influenced learning outcomes in physics and junior science respectively.

In this chapter, qualitative evidence in section 10.2 shows the extent to which students believed that such an approach impacted on their learning outcomes. Quantitative evidence (10.3), based on students' school exam results is examined to determine the extent to which these results were influenced by a blended web-based learning environment. The findings of this chapter is summarised in section 10.4.

10.2 QUALITATIVE EVIDENCE – WRITTEN SURVEYS

Qualitative data were gathered from students to ascertain the extent to which they believed that the web-based approach helped them with their learning. In their written questionnaires, students were asked a few specific questions in terms of whether the web-based approach helped them with their learning. Students in Year

12 physics classes in 2002 and 2003 were asked these questions. The responses from each group are discussed one by one.

10.2.1 Group I: Year Physics (2002)

Students in this group (N =16) were asked if the blended approach and *Getsmart* helped them with their learning. The majority of the students (85%) believed for various reasons that such an approach facilitated their learning. A variety of reasons were expressed to explain their answers:

Content provided is short and concise – it is easier to learn, multiple choice questions provide practice, challenging questions in the Forum assisted me to answer complex type questions.

Examples helped me understand how formulas work.

Yes, some concepts that I did not understand in class could be explained through online tutorials.

Multiple choice tests helped. If I got a question wrong, I could look back at the work and analyse why it is wrong.

The tutorials are helpful as they are concise and condensed notes and explanations. I prefer this than reading pages and pages... in the textbook.

The summaries and multiple choice tests really helped me revise what I had learnt over the term. The complex reasoning questions were a big help.

10.2.2 Group II: 12 Physics (2003)

Students in this group (N = 34) were asked three questions. In the first question they were asked if *Getsmart* improved their results in physics and they had to give reasons for their answers. Half of this group had been exposed to web-based learning over two years. The majority of the group (72%) were positive that the website did improve their results. Some of the reasons were expressed as follows:

Yes, I believe that "Getsmart" improved my Physics results because I learn by looking at examples. This website contains worked examples which helped me better understand the work done in class. Also, the tests at the end of each page helped in my revision before the exam.

Yes. It adds more variety to learning and made me more interested in the subject. The multiple choice tests allowed me to see if I really knew the work and how much (more) work I need to do. My results in science process have improved from a C to an A this term. I think the activity worksheets have helped me understand science processes better.

I believe it improved my marks because it explains things in different ways.

For the past 2 years I've just been passing physics and this term I ignored my teacher and just learnt from the textbook and Getsmart. Getsmart provided notes which I didn't get from my teacher.

Twenty-two percent of the population did not think that *Getsmart* improved their results and about 6% were not sure. It was interesting to note that all except one student in this group were male and almost 50% were from non-English speaking backgrounds. The reasons were varied such as *no time to commit to lessons*. Another student wrote:

It didn't because I am not a computer person. I dislike computers...that's why I don't access the website although the net is available to me at all times.

The second question asked whether students thought that it was a good idea to supplement in-class teaching with teacher developed websites such as *Getsmart.* More than 80% responded positively with reasons such as *individuals learn at their own pace...rather than at teacher's pace.* Other interesting reasons included:

People like me learn better from notes and when I didn't get notes from my teacher I relied on Getsmart.

Gives an opportunity to review the work without distraction and creates a greater opportunity to concentrate on the work.

Personally...I find it hard to follow lectures. Without the online notes...I had to write as the teacher spoke and that can become a frustrating task when I cannot keep up.

Getsmart improved my results without a shadow of doubt because it provides students with two different learning environments.

The design of *Getsmart* also tried to address the issue of the lack of feedback to science students. The report by Goodrum, Hackling, and Rennie (2001) pointed out that the quality of formative assessment and teacher feedback on student progress varied in schools. Only 7% of high school students were given a quiz to see how they going every lesson and 16% engaged in such formative assessment once a week. It was also interesting to note that 23% of the student population never had formative tests and almost one third never received any feedback from their teachers on how they were going in science. In *Getsmart,* one of the feedback opportunities provided to students was online tests at the end of each lesson. Students were given feedback on their performance and their results were written to a database which enabled them to track their progress. Students' responses in Chapters Seven and Eight demonstrated that these tests created positive perceptions.

In the third question students were asked to express their views on online tests. Three students in this sample chose not to respond. However, 90% of the students in this group had at least one positive comment about it. Varieties of reasons were expressed such as:

I think they are good; in that when you are done, you can see what you have done.

It provides an excellent opportunity to test what you know.

They help to make your understanding of the lesson more solid and in the long term it is easier to prepare like this for an exam.

Tests were an excellent way of understanding what you have just been taught.

One student wrote that online tests *work well because they make you think about which is the correct answer.* This response highlighted the reason why the test was designed in a manner that gave feedback on percentage correct but did not indicate the ones they had wrong. The idea was that a score of less than 100% would challenge students to reason for themselves. They could also discuss with their peers and teachers to identify correct answers. By doing so they had a much greater probability of learning more about the concepts underlying the question and seek the correct solution at the same time.

10.3 QUANTITATIVE EVIDENCE – EXAM RESULTS

In section 10.2, students' qualitative responses suggested that the blended approach influenced their learning outcomes. Did the exam results support their views which were expressed qualitatively? This section investigates the impact of *Getsmart* and the blended learning approach on students' performance in exams.

As discussed previously, for many people, exam results are regarded as the best indicators of how successful an innovative approach is. Therefore, the success of an innovative approach could be measured by comparing exam data with exams previously completed. However, school assessments are continuously changing which makes reliable data comparisons very difficult. Other important variations also occur such as teachers changing from one year to the next. Teachers' enthusiasm about an innovation can also be an important factor in terms of how students perceive the innovation from a learning perspective.

The senior physics course in Queensland is based on nine syllabus topics; Physical Quantities and Measurement, Force and Motion, Energy and Measurement, Thermal Physics, Optics, Wave Motion, Magnetism and Electricity, Electricity and Electronics, Atomic and Nuclear Physics. The impact of a blended learning approach on students in physics was studied by examining the assessment results of four physics groups. Three of these groups participated in this study at different times. The groups which participated are listed in Table 10.1.

Table 10.1

Description of the Blended Learning Groups A, B and C and the Traditional Learning Group D.

Group	Year(s)	Exposure to web-based learning (terms)	Details of web-based learning experience
		Blended learning groups	
A#	2002 & 2003	2	Year 11, Term 2 (2002) Year 12, Term 3 (2003)
B#	2002	1	Year 12, Term 3 (2002)
C	2003	1	Year 12, Term 3 (2003)
		Traditional learning group	
D#	2001	0	Nil (Control)

These classes had the same teacher.

Table 10.1 shows that three groups of students (A, B, & C) experienced the blended web-based learning approach. These groups have been described as the blended learning groups in the discussion which follows. Assessment data of these groups were compared with the results of the students in Group D (traditional learning group) who had never been exposed to such an approach. All the groups, except group C had the same physics teacher. Students were exposed to web-based learning for one term in a specific unit. The topics in the syllabus units that were available in the web-based mode are shown in Table 10.2.

Table 10.2

Web Lessons on Getsmart for Senior Physics Students

Lessons on *Getsmart*		
Topic 1 : Optics (11 Physics)		
➢ Plane mirrors ➢ Reflection in a curved mirror ➢ Ray diagrams (concave mirrors) ➢ Ray diagrams (convex mirrors)	➢ Mirror formula ➢ Practice ray diagrams (mirrors) ➢ Mirrors chapter summary ➢ Refraction	➢ Convex Lens ➢ Concave Lens ➢ Practice ray diagrams (lens) ➢ Lens formula ➢ Optics revision
Topic 2 : Motion (11 Physics)		
➢ Scalars & Vectors ➢ Speed & Velocity ➢ Acceleration ➢ Equations of motion ➢ Motion graphs(1)	➢ Motion graphs(2) ➢ Application of motion concepts ➢ Free falling objects ➢ Projectile motion ➢ Circular motion	➢ Non-uniform circular motion ➢ Review Questions(1), ➢ Review Question(2)
Topic 3 : Energy and Momentum (11 Physics)		
➢ Momentum ➢ Conservation of momentum ➢ Momentum Problems (1)	➢ Momentum Problems (2) ➢ Kinetic Energy ➢ Potential Energy ➢ Kinetic and Potential Energy combined	➢ Work and Energy ➢ Forces(1) ➢ Forces(2) ➢ Review Questions
Topic 4 : Electronics (12 Physics)		
➢ Semi conductors ➢ More on doping ➢ Common electronic components ➢ Capacitors	➢ Diodes ➢ Light Dependent Resistors in action ➢ Capacitors in action	➢ NPN & PNP Transistors ➢ Logic Gates ➢ Electronics Revision

Topic 5 : Atomic Physics (12 Physics)

➢ History of the atom ➢ The hydrogen atom ➢ Frank-Hertz Experiment	➢ Radioactivity ➢ Radioactivity data analysis	➢ Binding energy ➢ Atomic Physics Revision

Students in senior physics in Queensland schools are assessed in three areas; Knowledge, Science Processes, and Complex Reasoning Skills. The Knowledge section of the assessment examines students' abilities to recall and apply their knowledge to simple situations. Science Processes measure their abilities to collect, present, and interpret data. The Complex Reasoning Skills section measures their ability to apply themselves in problem solving situations. Assessments were predominantly based on written exams which were done at the end of each term. Additionally, there was a practical exam each semester in which students performed an experiment, then presented, and interpreted their results.

The senior physics course is done over two years in Years 11 and 12. The schooling year is comprised of four terms or two semesters and all assessments are done internally. Student work and all assessment instruments are monitored at the end of each year by a panel appointed by the Queensland Studies Authority. The final result in physics is a cumulative total of students' results over two years. Students' results have to meet relevant criteria before awards of a *Very High Achievement* (VHA), *High Achievement* (HA), *Sound Achievement* (SA), *Low Achievement* (LA) or *Very Low Achievement* (VLA) are given. The minimum requirements for each criterion are shown in Table 10.3.

Table 10.3

Minimum Requirements for Each Rating in the Three Performance Domains.

Rating	Minimum requirements		
	Knowledge (%)	Science Processes (%)	Complex Reasoning Skills (%)
VHA	> 80	> 80	> 60
HA	> 65	> 65	> 40
SA	> 45	> 45	> 0
LA	> 30	> 30	-
VLA	< 30	< 30	-

In the next two sections, the impact of a web-based learning environment on student results is analysed. Group A in this research was the only one which was exposed to the blended learning approach in two non-consecutive school terms. The performance of this group over the four semesters is discussed in section 10.3.1. In the second half of semester three (term two of Year 12); blended learning formed a part of the teaching regime for Groups A and C in 2003 and for Group B in 2002. Students in Group D did physics in 2001 without any web-based support. The performance of these four groups is discussed in sections 10.3.2, 10.3.3, and 10.3.4.

10.3.1 Performance of Physics Group A

In this study, Group A was special because it was exposed most to the web-based learning environment. The performance of this group over two years is shown in Figure 10.1. The profile shows the means obtained in each assessment for each section (Knowledge, Science Processes, and Complex Reasoning Skills) over this period. For discussion purposes, the assessments are numbered one to eight and numerous points on the sketches are labelled. This group was exposed to web-based learning when they were studying the Optics unit in Term 2 (Year 11). They experienced this learning environment for the second time when they studied the Electronics and Atomic Physics units in Term 3 (Year 12). (In Figure 10.1, assessment numbers two and seven were done after students experienced web-based learning.) At various other times web-lessons were available to students but not offered in a blended learning mode because Internet access was not available during school hours. The students had the same teacher for most of the time. However, the work covered prior to assessment eight was taught by a different teacher.

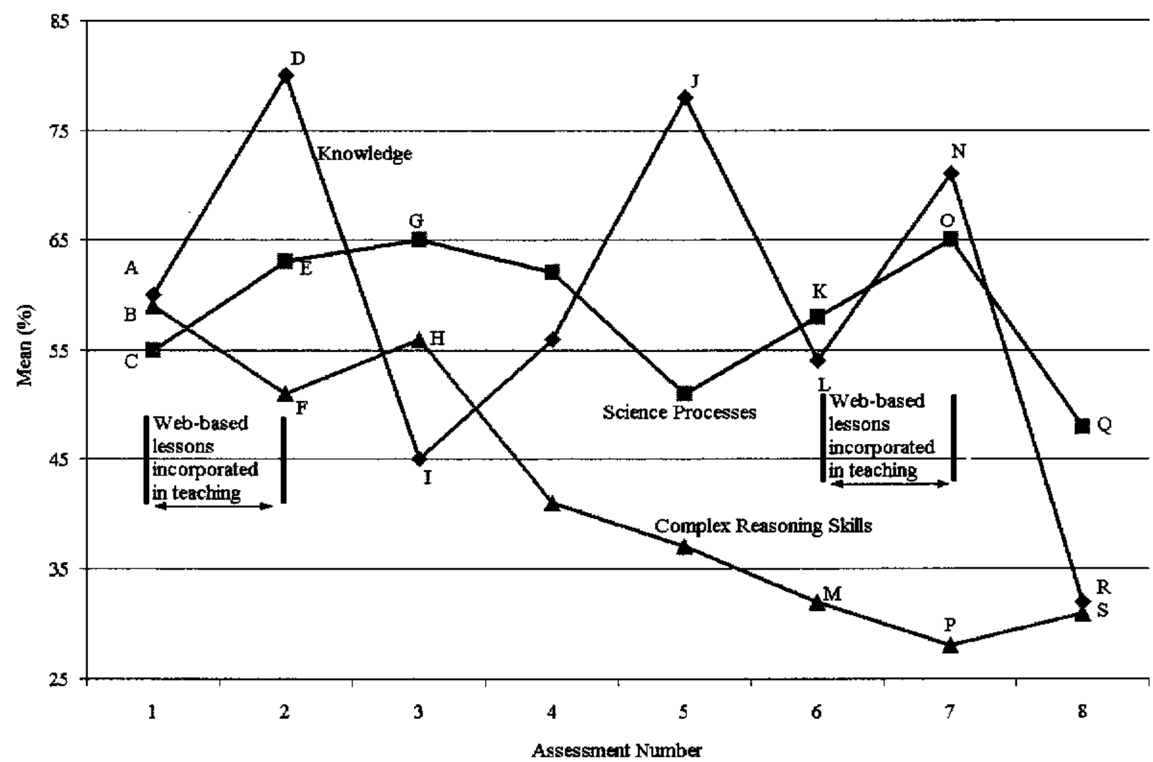


Figure 10.1. A profile of the performance of Group A students in Knowledge, Science Processes, and Complex Reasoning Skills assessments over two years.

In Figure 10.1, points A, B, and C correspond to the results obtained for each section at the end of term one (2002). This assessment was based on the Heat unit (Assessment number one). Web-based learning was introduced in term two for the Optics unit. As the profiles show (Assessment number two), Knowledge (Point D) and Science Processes (Point E) results improved but the results for Complex Reasoning Skills (Point F) decreased. A statistical analysis on the performance of this group for these two exams is presented in Table 10.4 in which the difference between end and mid-semester results (Assessment numbers one and two) for each section is depicted.

time. For this group, the teachers' observations suggested that they lacked the motivation and the drive to do additional work. Points G, H, and I (Figure 10.1) corresponded to the means of the Science Processes, Complex Reasoning Skills, and Knowledge results respectively in term three. While the means for Science Processes and Complex Reasoning Skills increased, the mean for the Knowledge results decreased greatly.

Point J is of significance. The high mean recorded in this instance was a result of a varied assessment approach for the Knowledge section. This was done within the traditional environment. Points K, L, and M (see Figure 10.4) corresponded to the means of the Knowledge, Science Processes, and Complex Reasoning assessments which were done at the end of semester three in Year 12 (semesters three and four are completed in Year 12). After these assessments, Knowledge and Science Process results were similar to what they were before web-based learning was introduced for this group the first time (see points B and C on Figure 10.4).

A blended learning approach was once again implemented and the Electronics and Atomic Physics unit. Knowledge and Science Process results increased (Points N and O) and the Complex Reasoning Skills results declined (Point P). A similar pattern was observed when a blended learning approach was introduced in the Optics unit in Year 11. A statistical analysis was once again carried out to investigate the differences between the end of semester 1 (Assessment Number Six) and mid-semester 2 (assessment Number Seven) results (Table 10.5).

Table 10.5

Performance of Physics Group A Before and After Web-based Learning in Semesters Three and Four (2003).

Assessment type	Difference in the means	Standard deviation (mid-sem.4)	Standard deviation (end-of-sem.3)	Effect size	Paired sample correlation
Knowledge	16.88**	15.95	20.70	0.91	0.70**
Science Processes	7.25	19.11	15.34	0.42	0.60*
Complex Reasoning Skills	-3.96	20.32	25.27	0.17	0.80**

Equals the difference in the means of mid-semester four (Assessment Number Seven) and end-of-semester three (Assessment Number Six) exams.
N = 16.
* p<0.05. ** p<0.01.

The results above are consistent with those observed when the Optics unit was taught in a blended learning environment. In the Optics section, effect sizes of 1.8, 0.49 and 0.31 were observed for Knowledge, Science Processes and Complex Reasoning results, respectively. In this case, effect sizes of 0.91, 0.42 and 0.17 show a similar pattern. It was also very interesting to note that there was similarity between the differences obtained in this instance and those reported in the Optics section (see Table 10.4). While there was a difference in the means, only the differences in the mean of the Knowledge results were statistically significant, $t(15) = 4.51$, $p<0.01$, with students achieving a higher mean in this section which was taught with a blended approach.

The correlation coefficients after the two blocks of blended learning were interesting. When web-based learning was introduced the first time (in semester one) correlation coefficients of 0.14, 0.37, and 0.36 (see Table 10.4) were achieved for the Knowledge, Science Processes and Complex Reasoning sections, respectively. However, these values rose the second time to 0.70 (Knowledge), 0.60 (Science Processes), and 0.80 (Complex Reasoning) for the three sections which showed that students were more established in their course and performing to their abilities. In this instance, the relative improvement within the group did not affect the relative position of the students in terms of their abilities.

The profile over the two years for this physics Group A (see Figure 10.1) shows a significant fluctuation in the means of the Knowledge results. The means for Science Processes results fluctuated but not to the same extent as Knowledge means. The Complex Reasoning Skills profile appears to have commenced its negative slide in term one of Year 11 and carried on (with the exception of point H) which suggests that even a blended learning approach could not arrest the decline for this class. Previous teacher observations suggest that such a decline was generally consistent with the results obtained by students studying physics.

The performance of the physics students in Group A, suggested that a web-based learning environment did seem to positively influence the Knowledge and Science Processes results. For this group such an approach did not seem to affect their performance in the Complex Reasoning section of the exams. The acquisition of Complex Reasoning Skills in physics depends largely on students' academic abilities. Additionally, it also depends on their ability to relate their understanding of the Knowledge and Science Process sections in unseen situations. Even in traditional classrooms, enhancing students Complex Reasoning skills is a challenging task. Perhaps new activities should be designed and added to *Getsmart* specifically aimed at improving students' complex reasoning abilities.

10.3.2 Comparison of the performances of Groups A, B, C and D in Knowledge assessments

The Knowledge section of the physics course assesses students' abilities to recall and apply knowledge in simple situations. Exam results accumulated from a number of years suggest that while this section is often perceived as the easiest, students usually seem to have a lot of problems. Although some teachers believe that students' unwillingness to learn the basics was the main reason for their performance, perhaps it is the way the basics are taught that makes the difference.

In this discussion, the performance of Groups A, B, C, and D are compared. Groups A, B and C participated in blended learning in the first half of semester four. Group D did not have this option. Figure 10.2 the shows the performance of the four groups.

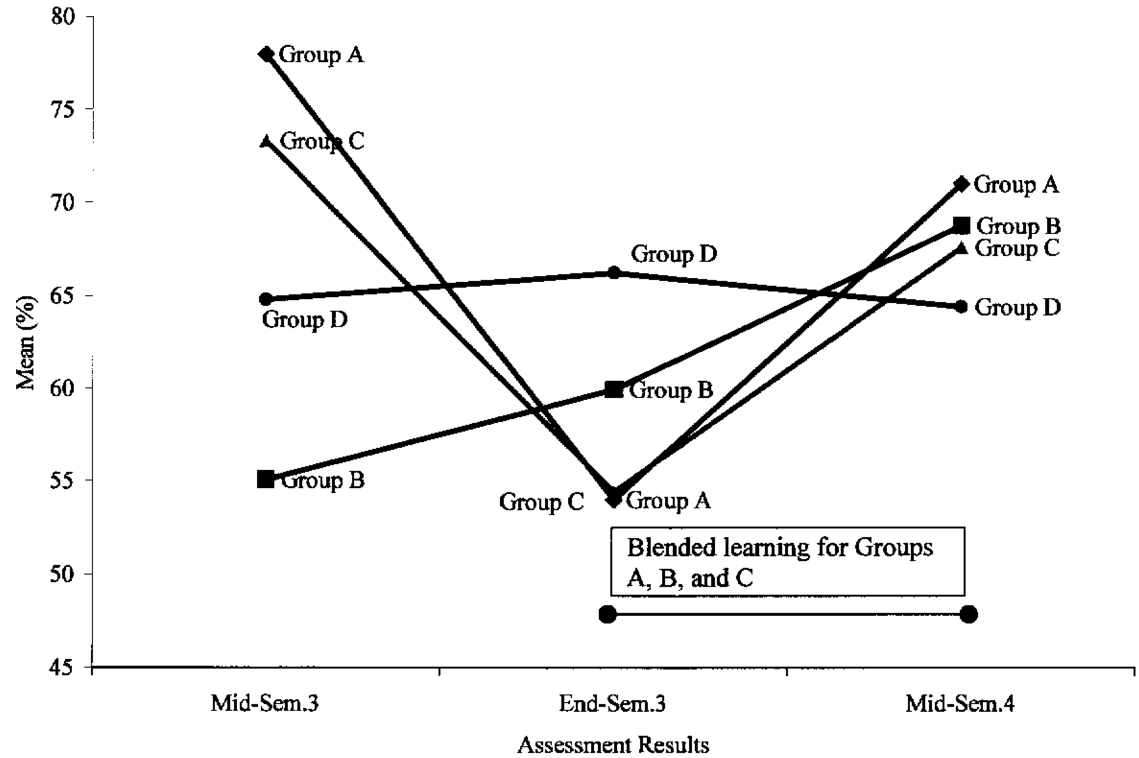


Figure 10.2. Profiles of Knowledge means for Groups A, B, C, and D in Year 12 physics exams.

The profiles in Figure 10.2 show that while Groups A and C had significant declines in their means results after the mid-semester three exam, for Groups B and D this was not an issue. Web-based learning was introduced after the end of semester three exams. The plots above show that for all three Groups (A, B and C), the results improved. It is also worth noting that no such change was noted for Group D; the group which was taught using traditional methods. A statistical analysis of end-of-semester three and mid-semester four knowledge results is presented in Table 10.6.

Table 10.6

Analysis of the Performance in the Knowledge Section for Groups A, B, C and D in End-of-Semester Three and Mid-Semester Four Exams.

Group	Sample size (N)	Difference in the means	Standard deviation (mid-sem.4)	Standard deviation (end-of-sem.3)	Effect size	Paired sample correlation
			Blended learning groups			
A	16	16.88**	15.95	20.70	0.91	0.70**
B	18	13.11 *	19.44	23.50	0.61	0.54**
C	15	8.80*	19.56	24.16	0.40	0.87**
			Traditional learning group			
D	33	1.82	18.19	11.98	0.12	0.75**

[#] Equals the difference in the means of mid-semester four and end-of-semester three exams.
*$p<0.05$. ** $p<0.01$.

The table above shows that the differences in the means of end-of-semester three and mid-semester four exams were statistically significant for Group A ($p<0.01$) and Groups B, and C ($p<0.05$) with higher means achieved in mid-semester four exams. The difference in the mean of Group D (traditional learning group) was not statistically significant. These differences correspond to effect sizes of 0.91, 0.61, and 0.40 for groups A, B, and C, respectively. These effect sizes ranged from medium to large. For Group D, a small effect size of 0.12 was observed. These results suggest that web-based learning may have impacted on student results in the knowledge section. The paired sample correlation was statistically significant ($p<0.01$) which suggests that although the results improved, the relative performance of the students was similar in both exams.

10.3.3 Comparison of the performances of Groups A, B, C, and D in Science Processes assessments

The Science Processes section measures students' abilities to present, analyse, and interpret data. Results obtained by students in pervious years have shown that in numerous instances, students could not achieve a higher overall rating for physics because of their inability to attain the required minimum standards in this performance domain. Consequently, science processes have also been a hurdle for some students. As in the previous section, the performances of the four groups were compared. The means attained by each group are shown in Figure 10.3.

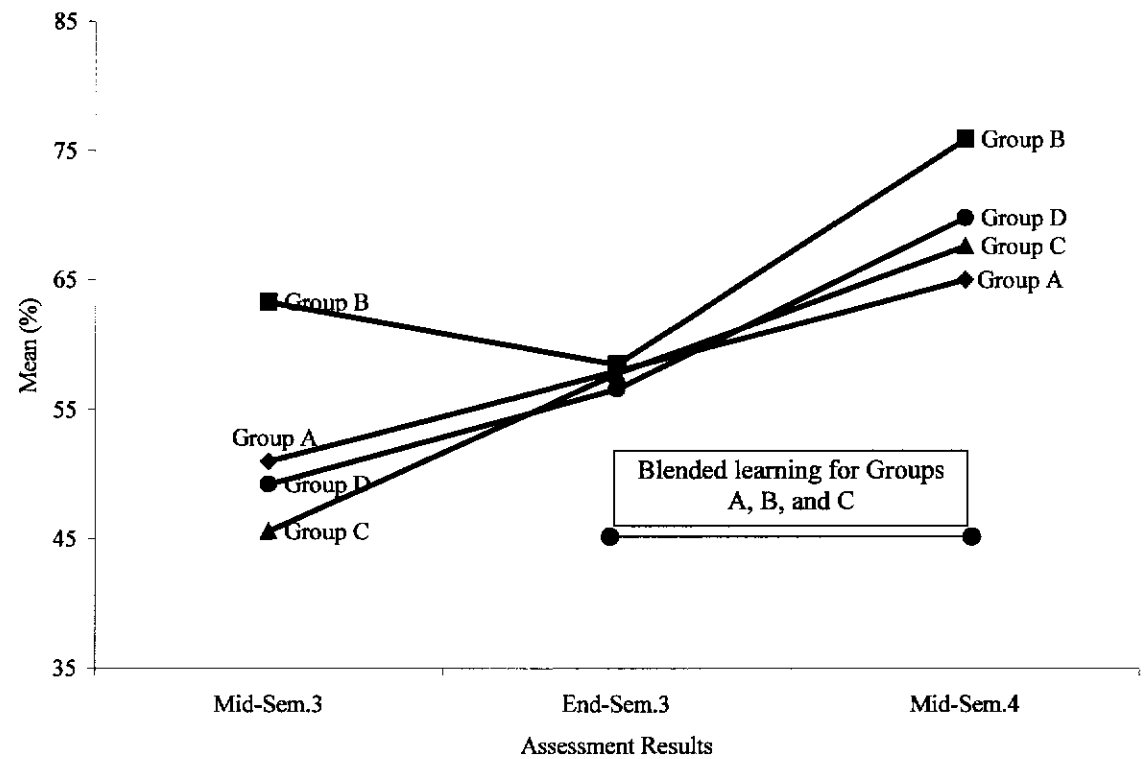


Figure 10.3. Profiles of Science Processes means for Groups A, B, C, D in Year 12 physics exams.

The profiles show that for all four groups, the results improved which suggests that web-based learning may not have made any significant difference on student performance in this section. Both these assessments (end-of-semester three and mid-semester four) included marks of the practical and written exams. These marks were included because these tests dealt with Electricity and Electronics; the two topics assessed in end-of-semester three and mid-semester four exams respectively. A statistical analysis of the end of semester three and mid-semester four results is presented in Table 10.7.

Table 10.7

Analysis of the performance in the Science Processes Section for Groups A, B, C and D in End-of-semester 3 and Mid-Semester 4 exams.

Group	Sample size (*N*)	Difference in the means#	Standard deviation (mid-sem.4)	Standard deviation (end-sem.3)	Effect size	Paired sample correlation
			Blended learning groups			
A	16	7.25	19.11	15.34	0.42	0.60*
B	15	17.33**	15.28	21.88	0.92	0.85**
C	18	9.78**	15.30	16.04	0.62	0.61**
			Traditional learning group			
D	33	13.21**	15.93	13.14	0.90	0.64**

Equals the difference in the means of mid-semester four and end-of-semester three exams.
*$p<0.05$. ** $p<0.01$.

The results presented in the table above suggest that web-based learning did not seem to have affected the results in the Science Processes assessments when compared with the results in the Knowledge section. The effect-sizes for the blended learning groups ranged from medium ($d = 0.42$) to large ($d = 0.92$). However, the traditional learning group also had a large effect size ($d = 0.90$). A paired sample t-test showed that the difference in the means was not only positive, but also statistically significant for Groups B, C, and D ($p<0.01$). The paired sample correlation was statistically significant for Group A ($p<0.05$) and Groups B, C, and D ($p<0.01$). The high values for correlation suggested that while the results improved, the relative performance of the students within the group did not change.

10.3.4 Comparison of the performances of Groups A, B, C, and D in Complex Reasoning Skills Assessments

The Complex Reasoning section is by far the most difficult because students have to apply themselves in solving unrehearsed questions. While, this is the rationale behind the design of this section, student results do not always show this to be case. A sketch of the performance of the four groups of students in this section is shown in Figure 10.4 below.

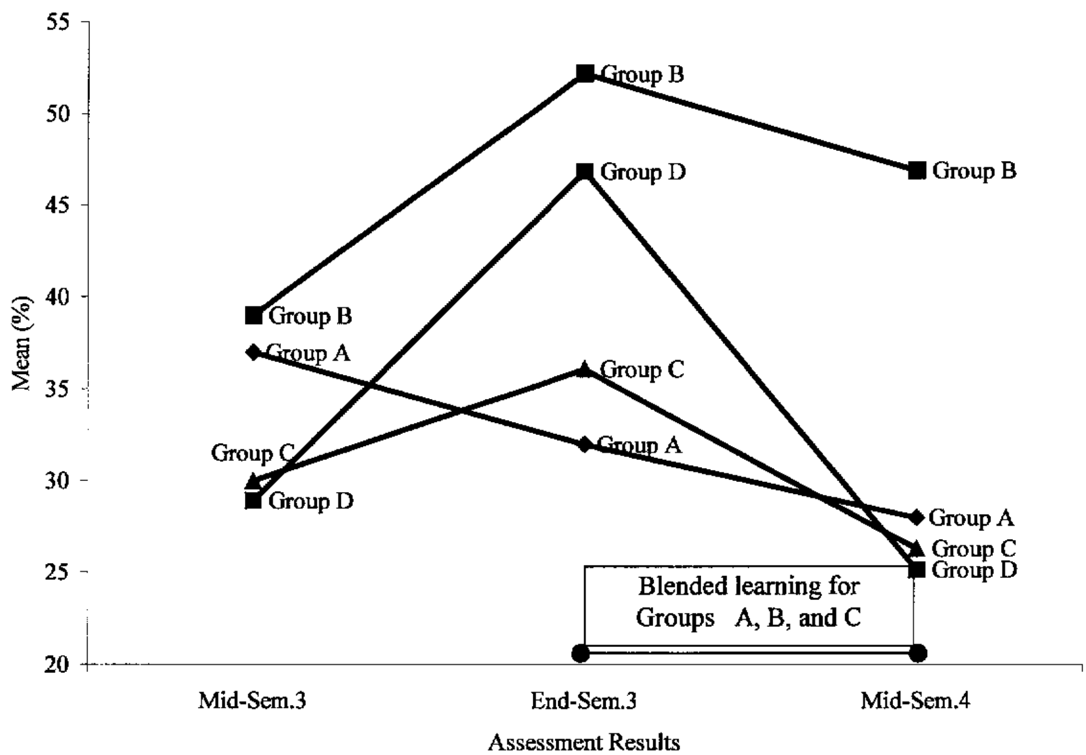


Figure 10.4. Profiles of Complex Reasoning Skills means for Groups A, B, C, and D in Year 12 physics exams.

The profiles above show that the results in this section declined after the end of semester three exams for all groups. However, while the decline in the mean of Group D was reflected by a larger negative slope, the slopes for the other groups were not as steep. Statistical analyses of the Complex Reasoning Skills results for the four groups were also carried out to measure the extent to which the results declined (Table 10.8).

Table 10.8

Analysis of the Performance in the Complex Reasoning Skills Section for Groups A, B, C and D in End-of-Semester Three and Mid-Semester Four exams.

Group	Sample size (N)	Difference in the means[#]	Standard deviation (mid-sem. 4)	Standard deviation (end-of-sem.3)	Effect size	Paired sample Correlation
			Blended learning groups			
A	16	-3.96	20.32	25.27	0.17	0.80
B	18	-9.82	21.20	29.16	0.39	0.59
C	15	-5.33	29.07	35.65	0.16	0.70
			Traditional learning group			
D	33	-21.72**	15.70	31.80	0.87	0.47

[#] Equals the difference in the means of mid-semester four and end-of-semester three exams.
* $p<0.05$. ** $p<0.01$.

The effect sizes in Table 10.8 explain the variation in the slopes of the four groups observed in Figure 10.4. While the means decreased for all four groups, the magnitudes of the effect sizes for the three groups that participated in web-based was much smaller than Group D (did not participate in web-based learning). These results suggest that web-based learning probably did help students achieve better results in this section. Evidence that supports this reasoning is the high effect sizes obtained for the Knowledge results for Groups A, B, and C which suggests that students have demonstrated a good knowledge and understanding of this topic. Consequently, if they have this understanding, then they should be able to demonstrate this in unseen situations which appear to be the case in this instance. High paired sample correlations between the mid and end-of-semester exams suggests that the relative performance of the students in the two exams was similar.

10.3.5 Comparison of the performances of Groups A, B, C, and D in terms of the overall results

The discussion above was centred on the three areas on which students are assessed in physics. While the overall results are not important for assessment purposes, for the purposes of this research it was viewed as a good indicator of students' performance in a blended learning environment. Profiles of the total means for Groups A to D is shown in Figure 10.5 below.

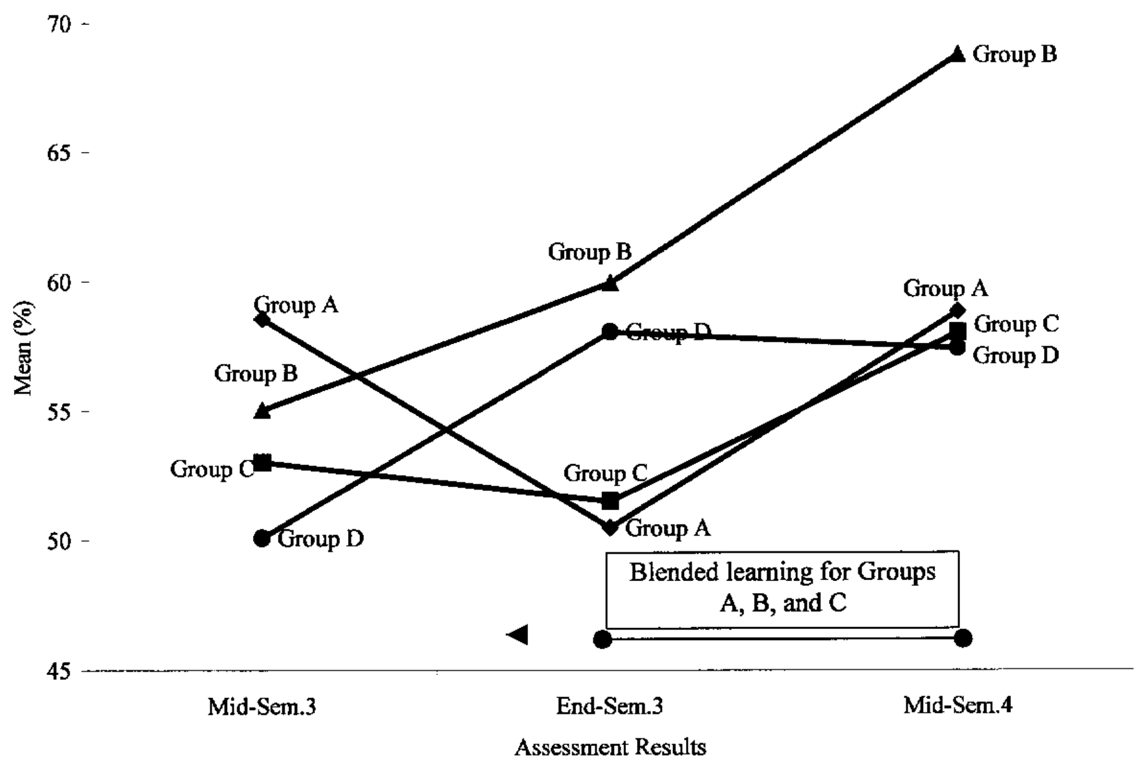


Figure 10.5. Profiles of total means (all three sections combined) for Groups A, B, C, and D in Year 12 physics exams.

The sketches above show that the overall means increased for Groups A, B, and C and dropped marginally for Group D. A statistical analysis of the difference in the overall means in end-of-semester three and mid-semester four exams is shown in Table 10.9

Table 10.9

Analysis of the Overall Performance of Groups A, B, C and D in End-of-semester Three and Mid-Semester Four exams.

Group	Sample size (N)	Difference in the means#	Standard deviation (mid-sem. 4)	Standard deviation (end-of-sem. 3)	Effect size	Paired sample Correlation
			Blended learning groups			
A	16	8.36**	16.20	16.98	0.50	0.93**
B	15	8.82**	18.36	23.11	0.42	0.94**
C	18	6.54*	15.66	18.75	0.38	0.74**
			Traditional learning group			
D	33	- 0.63	11.85	15.12	0.05	0.85**

Equals the difference in the means of mid-semester four and end-of-semester three exams.
* $p < 0.05$. ** $p < 0.01$.

The statistical values calculated in the table above, suggests that on the basis of the overall performance, blended learning seems to have influenced student results in senior physics. Medium effect sizes of 0.50, 0.42, and 0.38 for Groups A, B, and C, respectively suggests that a positive change occurred when mid-semester four results were compared with the results obtained at the end-of-semester three. An effect size of 0.05 in Group D, the group that did not have this exposure further supports the conclusion that web-based learning seems to have affected the learning outcomes of these students. This conclusion is well supported by the qualitative evidence which was presented earlier in this section. The paired sample correlation between the two assessments was high and positive for all four groups which suggests that the relative positions (in terms of academic achievement) of the students within each group probably changed little between assessments.

10.4 CHAPTER SUMMARY

The first section of this chapter presented qualitative data which showed that a vast majority of the students believed that the blended learning approach did influence their learning outcomes. A significant number also believed that this approach improved their performance in exams.

An analysis of the students' performance in their exams provided evidence which supported students' beliefs. This analysis focussed primarily on the performance of the four groups of students in the Knowledge, Science Processes and Complex Reasoning Skills sections of their exams. Their overall performance in the three sections was also analysed. The results showed that web-based appears to have influenced positively on students results in the Knowledge and Complex Reasoning Skills sections. No obvious conclusions could be drawn on the Science Processes results. It was also interesting to note that the blended learning approach did impact on students overall results in physics as well. The results presented in this chapter suggest that *Getsmart* and the blended learning approach did have some impact on students' results. The next chapter examines the impact of a web-based learning environment in junior science.

CHAPTER 11

THE IMPACT OF A WEB-BASED LEARNING ENVIRONMENT ON ACADEMIC ACHIEVEMENT IN JUNIOR SCIENCE

11.1 INTRODUCTION

In Chapter Ten, both qualitative and quantitative data suggested that the blended web-based learning approach impacted positively on students learning outcomes in senior physics. In this chapter, a similar analysis is carried out to establish if such an approach had an impact on the learning outcomes of junior science students. Qualitative evidence in section 11.2 shows the extent to which students believed that such an approach influenced their learning outcomes. In section 11.3, quantitative evidence based on students' school exam results is examined to determine the degree to which these results were influenced by a blended web-based learning environment. Section 11.4 explores the extent to which there is an association between students' perceptions of their web-based learning environment and their exam results. The findings of this chapter is summarised in section 11.5.

11.2 QUALITATIVE EVIDENCE – WRITTEN SURVEYS

Qualitative data were gathered from students to determine if they believed that the web-based approach helped them with their learning. In their written questionnaires, students were asked if web-based lessons helped them with their learning. Seventy two percent wrote yes, 23% wrote no, and 5% were uncommitted. In some instances, their performance in the exam appeared to have influenced their answers:

It helped me revise, by having everything I need to study.

I could still learn when I was at home and go over examples.

Everything was explained clearer...

The website helped me to learn...I did well in the exam which is better than I expected.

Worksheets completed during the lessons acted like revision sheets for the exam.

Yeah! I only just passed last term, this term I got a B^+ or something. It was great! Internet lessons all the way.

It was interesting to use online lessons, it was easier to learn and understand the information.

The site helped me to study ...because tests gave me an idea of what to work on...

It appeared that students who did not think that this approach to learning helped them, were the ones who preferred to learn in the presence of a teacher or with a textbook. A number of students did not believe that web lessons helped for reasons such as they *got the same result*. One student was having login problems; consequently, she felt that she *was falling behind.* Another student preferred to use the textbook because she did not have to *do the extra work from the Internet.* One male student summed up the reasons and the benefits for using the website via an email as follows:

I found that using the online learning technique was of great benefit to me when studying the topics incorporated in Advanced Science. Learning online enables the student to work at their own pace and in their preferred environment. I believe this allows students to attain and remain in a state of mind that enables a better understanding of the course material. This is also achieved using multimedia in the form of pictures, short animations, and interactive tasks. Students are also able to find out their progress and general understanding of the topics by taking online examinations that give results and feedback. In my opinion, the online course taken by the science class was highly beneficial to them and their results.

11.3 QUANTITATIVE EVIDENCE – EXAM RESULTS

Qualitative data presented in the previous section suggests that the majority of the students believed that web-based learning did influence their learning outcomes. As mentioned in the previous chapter, for many people exam results are regarded as the best indicators of how successful an innovative approach is. Therefore, the success of an innovative approach could be measured by comparing exam data with exams previously completed. However, school assessment instruments are continuously changing which makes reliable data comparisons very difficult. Other important variations also occur such as teachers changing from one year to the next and the variety in their expertise in the subjects can vary. While in the senior school, such a variation may not be significant (because teachers are often allocated classes based on their specialty) in the junior school, this can be a significant factor. For instance, in junior science, teachers teach topics in biology, chemistry, physics, and geology. Very few, if any would specialise in all areas. While teachers, do their level best in ensuring that they deliver the best lessons for their students, this may not always be possible. Such variations can influence results. Teachers' enthusiasm about an innovation can also be an important factor in terms of how students perceive the innovation from a learning perspective.

The Year 10 Advanced Science course was introduced at this school in 2003. Consequently, there was no exam data from previous years. For this reason, only the results of the Year 10 Science (2002) students are considered. Science students from nine classes (N = 261) participated in this study. These students studied units on consumer science and chemistry in term one. In the second term, web-based learning was introduced over a ten-week period and units on road science and space travel were taught. These units were relatively harder because the focus was on physics related concepts. An assessment of the degree of difficulty in this case was based on teacher observations and student results from previous years. Topics that were made available in the web-based mode are shown in Table 11.1.

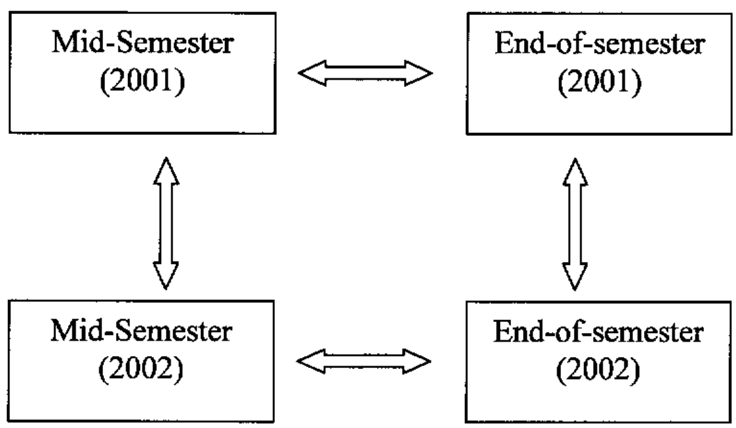
Table 11.1

Web Lessons Developed for Year 10 Science.

Topics	Lessons
Road Science	➢ What is speed?
	➢ What does a graph tell us?
	➢ What is acceleration?
	➢ Reaction time and reaction distance
	➢ Inertia
	➢ Force, mass and acceleration
	➢ Revision 1
	➢ Revision 2
Space Travel	➢ How does a rocket work?
	➢ Space Exploration
	➢ Space Travel Revision

The design of school-based exams and the emphasis of courses can change from one year to the next. In this instance, the teacher who coordinated the science course was the same in 2001 and 2002. She also wrote the tests. Therefore, in this discussion the changes to student performance possibly because of web-based learning, are based on the comparison test results obtained by the Year 10 science cohorts in 2001 and 2002.

Prior to 2003, the tests in junior science were designed to measure students' abilities in three performance domains; Knowledge, Science Processes, and Application. The Knowledge section of the test examined students' abilities to recall and apply their knowledge to simple situations. Science Processes measured their abilities to present and interpret data. The Application section measured their abilities to apply themselves in problem solving situations. Student assessment was based on mid and end semester tests and a cumulative mark for their laboratory practical reports (based on their semester's work). The results for the Knowledge and Application sections in 2001 were easily obtained. However, the results for the end-of-semester Science Processes section were not readily available because it was based on students' performance in the end-of-semester exam plus their cumulative mark for their laboratory reports. Hence, in this study the discussion is focused on Knowledge and Application results only. Data comparisons were done between years and within years as follows:



Wherever possible, effect sizes (*d*) were also calculated. According to Morris and DeShon (2003), effect size measured the amount of change produced by an intervention. The significance of effect sizes can be described as small (d = 0.2), medium (d = 0.5), or large (d = 0.8) (Cohen, 1988). These values can also be interpreted in terms of the proportion of scores which changed when two situations were compared with one another. For instance, an effect size of 0.2 suggests that 58% of the scores in group one would be expected to fall above the mean of group two, an effect size of 0.5 suggests that 69% of the scores in group one would be expected to fall above the mean of group two and so on (Morris & DeShon, 1988). Independent and paired-sample t-tests were also calculated to establish the significance of the difference in the means.

11.3.1 Comparison of 2002 and 2003 science results

Initially, a comparison of the results obtained by students in 2001 and 2002 was carried out. For discussion purposes, the group in 2001 is described as the traditional learning group and the group in 2002 is described as the blended learning group. It was found that there was almost no difference in the means of the two groups for their mid-semester exam which suggested that the two groups were similar in terms of academic ability. The difference in the means of the mid-semester Knowledge and Application results obtained in 2001 and 2002 is tabulated below (Table 11.2).

Table 11.2

Comparison of Mid and End-of-Semester Knowledge and Application Results for Year 10 Science in 2001 and 2002.

Assessment Identification	Difference in the means#	Standard deviation (2002)	Standard deviation (2001)	Effect size
		Knowledge		
Mid-semester	-0.35	21.44	20.84	0.02
End-of-semester	6.90**	17.96	20.60	0.36
		Application		
Mid-semester	3.23	23.49	24.46	0.13
End-of-semester	0.32	30.09	33.84	0.01

Equals the difference in the means of 2002 and 2001 exams.
$N = 214$ (2001). $N = 244$ (2002).
** $p<0.01$.

As shown in Table 11.2, while there was almost no difference between the means obtained in the mid-semester Knowledge results in 2002 and 2003, there was a difference between the means obtained in the end of semester exams. There was a significant effect for the end of semester Knowledge results, $t(456) = 3.83$, $p<0.01$, with students receiving higher scores in 2002 than in 2001. This observation suggests that web-based learning possibly impacted on students learning outcomes in the Knowledge section of the exam. There was an effect size of 0.36 which also suggests that the innovation had a small effect on student performance. For the Knowledge results in 2001, the standard deviation remained almost the same, but in 2002, it fell from 21.44 to 17.96. This result suggested that a decline in the spread of the scores occurred possibly because of web-based learning.

In the Application section, the difference in the means was almost negligible and was not statistically significant. The standard deviation for the Application section in 2002 was lower than the value calculated in 2001 for the end-of-semester exams. The results in the Table 11.2 suggest that while the Application results did not show a significant difference, the Knowledge results did. For this reason, further comparisons were carried out to identify the group or groups whose performances were affected. A comparison was done initially between mid and end-of-semester results for knowledge and application results in each year.

Table 11.3

Comparison of Mid and End-of-Semester Knowledge and Application results for Year 10 Science in 2001 and 2002.

Assessment type	Difference in the means#	Standard deviation (end-of-semester)	Standard deviation (mid-semester)	Effect size
	Traditional learning group (2001) ($N = 214$)			
Knowledge	-5.31**	20.60	20.84	0.26
Application	-7.80 **	33.84	24.46	0.26
	Blended learning group (2002) ($N = 244$)			
Knowledge	0.26	19.07	20.02	0.01
Application	-12.16**	30.15	22.63	0.46

Equals the difference in the means of the end and mid-semester exams.
**$p<0.01$

Table 11.3 shows that while the mean for the Knowledge results for the group in 2001 decreased, this was not the case for the group in 2002. This decline in the mean was statistically significant ($t(213) = 4.94$, $p<0.01$). The marginal increase in the mean for the Knowledge section in 2002 was not statistically significant. On the other hand, the difference in the means for the Application results was greater in 2002. Both the differences (2001, 2002) observed with the Application results were statistically significant ($p<0.01$) with students achieving lower means in the end-of-semester exams. These results suggest that while web-based learning influenced positively on the Knowledge results, it appeared to have had a negative effect on results in the Application section.

11.3.2 Student performance in quartiles

An analysis was carried out to see how students in each quartile performed in 2001 and 2002. The quartiles were determined on the basis of the marks obtained in the Knowledge section of the end-of-semester exams. The results for the students in the first quartile are presented in Table 11.4.

Table 11.4

Mid and End-of-semester Results for Year 10 Science (2001 and 2002) for the First Quartile.

Assessment type	Difference in the means#	Standard deviation (end-of-semester)	Standard deviation (mid-semester)	Effect size	Paired sample correlation
		Traditional learning group (2001) (N = 55)			
Knowledge	-0.80	5.09	6.67	0.13	0.30*
Application	-7.18*	17.62	16.10	0.43	0.14
		Blended learning group (2002) (N = 61)			
Knowledge	8.72**	4.32	16.40	0.73	0.29
Application	0.90	23.51	16.85	0.04	0.10

Equals the difference in the means of the end and mid-semester exams.
*$p<0.05$. **$p<0.01$.

The Knowledge mean for student scores in the first quartile in 2001 remained relatively unchanged between the two exams. There was a significant effect for the results obtained in the Application section, $t(54) = 2.41$, $p<0.05$, with students achieving higher scores in the mid-semester than end-of-semester exams. This decline in performance was associated with almost a medium effect size ($d = 0.43$).

These results were different for the group in 2002. There was a significant effect for the difference in the means of the Knowledge section ($t(60) = 4.16$, $p< 0.01$), with students achieving higher scores in the end-of-semester than mid-semester exams. An effect size of 0.73 suggested that the difference in the Knowledge mean could almost be described as large.

The paired sample correlation was almost the same in both years. However, a comparison of the difference in the means, suggest that web-based learning probably influenced students' performances in first quartile for the Knowledge section. The difference in the means in 2002 was statistically significant ($p<0.01$) whereas in the previous year there was almost no difference in the means (see Table 11.4). Similarly, it also appears to have influenced student results in the Application section because in 2001 the mean for this section in this exam had declined significantly ($p<0.05$), whereas in 2002 the means were unaffected. A similar investigation was carried out for students in the second quartile (Table 11.5).

Table 11.6

Mid and End-of-Semester Results for Year 10 Science (2001 and 2002) for the Third Quartile.

Assessment type	Difference in the means#	Standard deviation (end -semester)	Standard deviation (mid-semester)	Effect size	Paired sample correlation
		Traditional learning group (2001) (N = 55)			
Knowledge	-1.56	4.90	17.35	0.12	0.04
Application	-14.18**	21.76	18.81	0.70	-0.08
		Blended learning group (2002) (N = 61)			
Knowledge	0.33	4.14	18.78	0.02	0.31
Application	-16.72**	24.76	22.52	0.71	0.42*

Equals the difference in the means of the end and mid-semester exams.

* $p<0.05$. ** $p<0.01$.

The results of the third quartile shown in the table above are interesting. Based on the difference in means, it appears that in both years' students appear to have performed similarly. The differences in the Knowledge means improved. The differences in the Application results were statistically significant ($p<0.01$) in both years. The change in the standard deviations for the Knowledge exam is consistent with the first two quartiles (see Tables 11.4 and 11.5). In both years, the spread in the scores changes for the Knowledge exam by a factor of four. For instance, the standard deviation in 2002 changed from 18.78 to 4.14 which suggests that student results were clustered around each other to a greater degree at the end of the semester. The effect size was large for the differences in the Application results in both years. These results imply that unlike students in quartiles one and two, these students were least advantaged by web-based learning.

While in 2001, the paired sample correlation was almost equal to zero, in 2002, there was a positive correlation between the Knowledge and Application results. The latter was statistically significant ($p<0.05$). Unlike 2001, in 2002 there was some consistency in terms of how students in this quartile performed in the two exams.

Interestingly, these values for the paired sample correlations appear to be reversed when compared with the correlation coefficients obtained for the second quartile (see Table 11.5). Table 11.7 compares the results of the fourth quartile.

Table 11.7

Mid and End-of-Semester Results for Year 10 Science (2001 and 2002) for the Fourth Quartile.

Assessment type	Difference in the means[#]	Standard deviation (end-of-semester)	Standard deviation (mid-semester)	Effect size	Paired sample correlation
Traditional learning group (2001) (N = 55)					
Knowledge	-14.33*	13.31	20.10	0.84	0.38*
Application	-17.68*	14.30	21.63	0.96	0.50**
Blended learning group 2002 (N = 60)					
Knowledge	4.50	11.36	20.60	0.27	0.39*
Application	-24.26*	19.18	23.40	1.13	0.40**

[#] Equals the difference in the means of the end and mid-semester exams.
* $p<0.05$. ** $p<0.01$.

The table above shows that in 2001 there was a significant effect for the difference in Knowledge ($t(53) = -5.43, p<0.01$) and Application ($t(53) = -6.84, p<0.01$) means with students obtaining higher scores in mid-semester than in the end-of-semester exams. In 2002, there was a similar significant effect for the results obtained in the Application section, $t(59) = -9.32, p<0.01$, with students achieving higher scores in the mid-semester than end-of-semester exams. However, after the blended learning experience it appears that students achieved a higher mean in their end of semester exams. While this difference was not statistically significant, it improved significantly from a difference of -14.33 (d = 0.84) in 2001 to 4.50 (d = 0.27) in 2002.

As in previous cases, the results for the Application section declined in the end of semester exam in both years. For this reason, while web-based learning did not seem to influence the results in the Application section, it did produce a positive gain in the Knowledge results in the end-of-semester exams. It is also interesting that the paired sample correlation was strongly positive and significant ($p<0.01$) in both years.

For teachers this result is significant. It shows that when students are provided with the right learning environment, their results can improve to a certain degree. The discussion on the quartiles shows two interesting patterns with the students in 2002. The effect size on the differences in the Knowledge means almost diminished with the quartiles with values of 0.73, 0.34, 0.02, and 0.27 calculated for quartiles one, two, three, and four, respectively. Comparatively, in 2001, the decrease in the means corresponded to effect sizes of 0.13, 0.43, 0.12, and 0.84 were determined for quartiles one through to four respectively. On the other hand, the effect size became larger for the difference in the Application means in 2002 with values of 0.04, 0.13, 0.71, 1.13 for quartiles one, two, three, and four respectively. Comparatively, in 2001 values of 0.43, 0.24, 0.70, and 0.96 were calculated for quartiles one to four respectively. From these effect sizes, it is also evident that at least for half the population (quartiles one and two) in 2002, the difference in Application means was higher in comparison to similar quartiles in 2001. These results suggest that web-based learning appears to have influenced students learning outcomes to varying degrees. It enhanced Knowledge results for students with a variety of abilities. While the Application results were influenced to a certain degree for some students, the variations were not as noteworthy as the Knowledge results.

11.4 ASSOCIATION BETWEEN STUDENTS' PERCEPTIONS AND ACADEMIC ACHIEVEMENT

One of the aspects of this research was to investigate the connection between students' perceptions of their web-based learning environment and their academic achievement. This investigation could not be carried out with the physics students because of a small sample size. However, a larger sample with the junior science group enabled statistical analysis of the data across the four scales of the WEBLEI and students' results in the Knowledge and Application sections of their end-of-semester exams. The data was analysed to see if a linear relationship existed between the four scales of the WEBLEI and the end-of-semester exam results. These results are presented in Table 11.8.

Table 11.8

Associations between the WEBLEI scales and the End-of-Semester Knowledge and Application results in Terms of Simple Correlation (r) and the Standardized Regression Coefficients (beta).

WEBLEI Scales	End-of-Semester Knowledge Results		End-of-Semester Application Results	
	r	*beta*	*r*	*beta*
Access	0.00	- 0.03	0.00	- 0.01
Interaction	0.01	- 0.02	- 0.04	- 0.10
Response	0.03	0.04	0.00	- 0.02
Results	0.02	0.03	0.05	0.13
Multiple R Correlation	0.046		0.102	
R^2	0.002		0.010	

N = 165.

Correlation and Standardised Regression Coefficients in Table 11.8 suggest that there was no relationship in terms of students' results in their exams and their responses across the four scales of the WEBLEI. This investigation was extended to ascertain how students in each quartile (based on Knowledge results in the end-of-semester exam) responded to the WEBLEI survey. These results are presented in Table 11.9.

Table 11.9

Descriptive Statistics of the WEBLEI Scales based on the Quartiles of the End-of-Semester Exam Results (2002).

WEBLEI Scales	Descriptive Statistics		
	Mean	Standard Deviation	Valid Cases
	First quartile		
Access	3.80	0.73	45
Interaction	3.45	0.70	45
Response	3.77	0.66	44
Results	3.86	0.66	45
	Second quartile		
Access	3.89	0.69	45
Interaction	3.34	0.84	45
Response	3.89	0.65	42
Results	3.89	0.66	45
	Third quartile		
Access	3.93	0.57	45
Interaction	3.51	0.86	44
Response	3.80	0.65	42
Results	3.68	0.67	44
	Fourth quartile		
Access	3.97	0.73	48
Interaction	3.51	0.75	47
Response	3.77	0.79	48
Results	3.98	0.69	47

The results obtained across the four quartiles and the four scales were interesting. All students regardless of how they performed in the exam appeared to have positive perceptions of their web-based learning environment. The students in the fourth quartile (students who scored less than 47% in the exam) obtained means that compared favourably with other quartiles across all four scales. They scored marginally higher means for the Access and Results scales. The profiles of the means across the WEBLEI scales for each quartile are sketched in Figure 11.1.

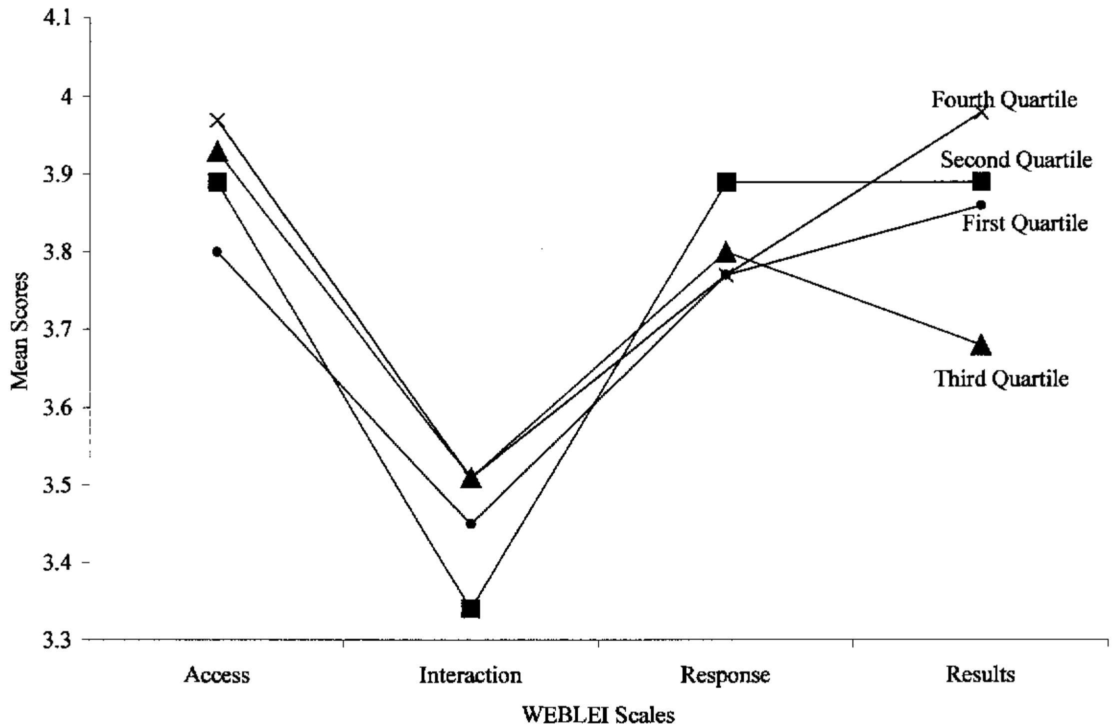


Figure 11.1. Profiles of the Mean WEBLEI Scores for Quartiles 1, 2, 3, and 4 for the junior science sample.

Students' response to the WEBLEI survey in the four quartiles explains why the statistical calculations (see Table 11.8) showed no relationship between the WEBLEI scales and exam results. As discussed earlier students' perceptions were unrelated to how they performed in the exams even though the WEBLEI was administered to them at the end of the term and after they had seen their exam results. These results also show that students in all four ability groups had similar perceptions to web-based learning approach.

11.5 CHAPTER SUMMARY

In this chapter, the results of two groups of students in Year 10 science were analysed. The group in 2001 was the traditional learning group and the group in 2002 was the blended learning group. The analysis showed that in comparison to the results obtained in 2001, the students did significantly better in the Knowledge section of their end of semester exams after experiencing web-based learning. No difference was found in the Application results. However, when this analysis was performed with the results obtained by the blended group in the mid-semester exams, there was no difference in the Knowledge results and the Application results declined. Comparatively, for the group in 2001, results in both these sections had declined.

Further analysis of the results on the basis of their performance in quartiles showed that in comparison to similar quartiles in 2001, students in quartiles one and two in 2002, did better in both sections of the exam. A similar comparison with the students in 2001 showed that the performance of students in quartile three was almost the same whereas in quartile four students did significantly better in the Knowledge section but did not do as well in the Application section.

Statistical analysis of the WEBLEI data and exam results showed that there was no relationship between students' perceptions and their performance in exams. Further analysis of the WEBLEI data explained the reason for this observation. When the WEBLEI survey results were compared across the four quartiles, it was found that all students had similar perceptions of their web-based learning environment. This leads to the belief that students' appear to have positive perceptions of their learning environment irrespective of how they perform in their exams. From a teacher's point of view, such a result is significant because it shows that a well designed website can capture the attention of all students. The next chapter investigates the impact of a blended web-based learning environment on boys and girls in junior science.

CHAPTER 12

THE IMPACT OF A WEB-BASED LEARNING ENVIRONMENT ON THE ACADEMIC ACHIEVEMENT OF BOYS AND GIRLS

12.1 INTRODUCTION

The impact of technology on gender has been reported in numerous studies. Bunt and D'Souza (2002) for instance, reported that there was no significant difference in test scores between males and females in a blended learning environment. They believed that the Internet appeared to be as good a teaching method as a lecture. However, females did not recall as much information as males after a lecture. Bunt and D'Souza (2002) concluded that a standard lecture could be detrimental to female learning and they suggested that the teaching web-based learning should be explored further to provide a fairer learning environment for both sexes. The conclusions of such studies do not demonstrate any universal trends, because the success of technology in teaching varies from one situation to the next. Any new educational initiative should cater for the needs of all students.

In this thesis so far, Chapters 10 and 11 showed that web-based learning did influence various aspects of students' performance in junior science and senior physics. In Chapter Seven it was established there was no difference between boys and girls in terms of their perceptions of a web-based learning environment. Was this also the case in terms of academic achievement? This chapter investigates the impact of a web-based learning environment on boys and girls in junior science. Such an investigation was not possible with the physics students because of a small sample size.

In section 12.2, the performance of boys and girls in 2001 and 2002 is compared. In section 12.3, the analysis is extended to compare the performance of boys and girls in each quartile. In sections 12.4 and 12.5, the performance of boys and girls is investigated independently. Section 12.6 presents a chapter summary.

12.2 PERFORMANCE OF BOYS AND GIRLS IN 2001 AND 2002

Science results of Year 10 students in 2001 and 2002 were compared in the previous chapter (see section 11.3.1). As explained earlier, the group in 2002 experienced web-based learning whereas the group in 2001 was taught solely by traditional methods. For discussion purposes, the group in 2001 is described as the traditional learning group and the group in 2002 is described as the blended learning group. The difference in the results of boys and girls for each year was initially investigated. Table 12.1 presents mid and end-of-semester results for boys and girls in Year 10 science in 2001 and 2002.

Table 12.1

Analysis of the Difference in the Mid and End-of-Semester Results for Boys and Girls in Year 10 Science in 2001 and 2002.

Assessment type	Difference in the means#	Standard deviation (girls)	Standard deviation (boys)
Traditional learning group (2001) ($N = 214$)			
Knowledge (mid-semester)	8.73*	18.20	22.36
Knowledge (end-of-semester)	3.42	19.70	21.37
Application (mid-semester)	-0.77	24.33	24.70
Application (end-of-semester)	3.61	33.21	34.50
Blended learning group (2002) ($N = 244$)			
Knowledge (mid-semester)	2.81	20.02	22.38
Knowledge (end-of-semester)	-2.08	17.87	18.03
Application (mid-semester)	0.92	22.45	24.27
Application (end-of-semester)	-4.01	29.34	30.60

Difference in the means equals the mean score of the girls minus the mean score of the boys.
* $p < 0.05$.

The data in Table 12.1 shows that the overall performance of girls in 2001 was generally better than boys in both Knowledge and Application sections of mid and end-of-semester exams. An independent samples t-test showed that the difference in the means of the Knowledge results for the two groups in 2001 was statistically significant ($p<0.05$) with girls achieving a higher mean than did boys. In 2002, the girls did better than boys in both sections in their mid-semester exams whereas the boys reversed this difference in the end of semester exams. Even though the boys did better in the end of semester exam, the differences were small and statistically insignificant. Hence, any increase or decline has not been at the expense of either gender group.

12.3 A COMPARISON OF THE PERFORMANCE OF BOYS AND GIRLS ACROSS QUARTILES

In Chapter 11, there was an extensive comparison of how the students performed in each quartile (see section 11.3.2). These quartiles were based on students performance in the Knowledge section of their end-of-semester exams. In this section, this investigation was extended to see how the boys and girls performed in each of these quartiles over the two years. Students performance in the Knowledge section is presented in Table 12.2.

Table 12.2

Comparison of the Difference in the Performance of Boys and Girls in Year 10 Science exams in 2001 and 2002 (Based on Quartiles).

Year	Quartiles#	Difference in means##	Standard deviation (girls)	Standard deviation (boys)	Effect Size
		Knowledge Results (mid-semester)			
2001	1	1.76	7.20	5.93	0.27
	2	8.85	8.91	5.07	1.22
	3	5.82	16.98	17.64	0.34
	4	10.32	18.94	20.1	0.53
2002	1	-1.61	21.77	12.4	0.09
	2	4.01	13.58	17.01	0.26
	3	11.40*	14.18	20.92	0.64
	4	5.14	17.56	22.86	0.25
		Knowledge Results (end-of-semester)			
2001	1	-0.09	5.24	5	0.02
	2	0.93	5.07	4.85	0.19
	3	0.09	4.96	4.93	0.02
	4	1.05	10.70	15.11	0.08
2002	1	1.14	4.31	4.34	0.26
	2	-0.50	2.52	2.88	0.18
	3	-0.36	3.83	4.45	0.09
	4	2.21	11.19	11.56	0.19

2002 Sample
Quartile 1 *N* (girls) = 23, *N* (boys) = 38
Quartile 2 *N* (girls) = 21, *N* (boys) = 40
Quartile 3 *N* (girls) = 29, *N* (boys) = 32
Quartile 4 *N* (girls) = 28, *N* (boys) = 32

2001 Sample
Quartile 1 *N* (girls) = 31, *N* (boys) = 24
Quartile 2 *N* (girls) = 23, *N* (boys) = 32
Quartile 3 *N* (girls) = 31, *N* (boys) = 24
Quartile 4 *N* (girls) = 23, *N* (boys) = 31

Difference in the means equals the mean score of the girls minus the mean score of the boys.
* $p<0.05$.

The results in Table 12.2 demonstrate some interesting patterns. In the mid-semester exam, in both years, the difference between the means of girls and boys for the Knowledge exam increased from quartiles one to four (quartile three was the only exception). However, in both years the difference between the means diminished considerably at the end of the semester. Comparatively, the magnitude of the effect sizes also declined considerably in the end-of-semester exam. One possible reason for this change lies in nature of the topics taught in the second half of the semester. These topics were Road Science and Space Travel which may have captured the attention of boys to a greater extent than girls. Consumer Science and Electrochemistry were taught in the first half of the semester which may have had an opposite effect on the two groups. A similar analysis was carried out to investigate students' performance in the Application section of their exams. These results are presented in Table 12.3.

Table 12.3

A Comparison of the Difference in the Performance of Boys and Girls in the Application Section of the Year 10 Science Exam Results in 2001 and 2002.

Year	Quartiles#	Difference in means##	Standard deviation (girls)	Standard deviation (boys)	Effect Size
		Application (mid-semester)			
2001	1	-0.61	16.86	15.41	-0.04
	2	1.01	18.26	18.48	0.05
	3	-9.13	17.52	19.54	-0.49
	4	-3.40	18.22	24.04	-0.16
2002	1	-0.51	20.79	14.26	-0.03
	2	2.88	16.73	22.60	0.14
	3	2.86	21.19	23.92	0.13
	4	3.77	21.90	24.81	0.16
		Application (end-of-semester)			
2001	1	1.78	17.64	17.93	0.10
	2	-9.53	25.40	30.31	-0.34
	3	5.99	24.94	16.70	0.28
	4	3.16	14.80	13.98	0.22
2002	1	-1.61	21.69	24.82	-0.07
	2	-2.26	23.64	20.52	-0.10
	3	-1.74	26.09	23.88	-0.07
	4	2.74	16.85	21.13	0.14

2002 Sample
Quartile 1 *N* (girls) = 23, *N* (boys) = 38
Quartile 2 *N* (girls) = 21, *N* (boys) = 40
Quartile 3 *N* (girls) = 29, *N* (boys) = 32
Quartile 4 *N* (girls) = 28, *N* (boys) = 32

2001 Sample
Quartile 1 *N* (girls) = 31, *N* (boys) = 24
Quartile 2 *N* (girls) = 23, *N* (boys) = 32
Quartile 3 *N* (girls) = 31, *N* (boys) = 24
Quartile 4 *N* (girls) = 23, *N* (boys) = 31

Difference in the means equals the mean score of the girls minus the mean score of the boys.
* $p<0.05$.

The differences in the means of the Application results did not show any consistent patterns in 2001 (Table 12.3). In the mid-semester exam, the differences in the means ranged from -9.13 to 1.01. In the end-of-semester exam, the differences ranged from 5.99 to -9.53. On the other hand, in 2002, the differences in the means of the mid- semester exam were -0.51, 2.88, 2.86 and 3.77 for quartiles one to four respectively, suggesting that the girls did marginally better than the boys. The differences in the means for the end of semester exam were -1.61, -2.26, -1.74 and 2.74 which suggested that the boys did slightly better than the girls. However, none of these differences were statistically significant.

On the basis of these results, it would be reasonable to suggest that on an exam by exam basis, a blended learning approach did not benefit one group (in terms of their abilities and gender) any more than the other for either section of the exam. The next two sections investigates the performance of each group independently.

12.4 PERFORMANCE OF BOYS

Did the boys perform any better as a result of web-based learning? In order to answer this question, a comparison of the performance of boys in 2001 and 2002 was initially carried out. These results are presented in Table 12.4.

Table 12.4

Performance of Boys in Year 10 Science Exams in 2001 and 2002.

Year	Sample Size	Difference in means#	Standard Deviation (End-of-Semester)	Standard Deviation (Mid-Semester)	Effect Size
			Knowledge Results		
2001	111	-2.81	22.29	23.02	0.12
2002	142	2.63	17.93	20.21	0.14
			Application Results		
2001	111	-9.77	34.70	25.54	0.32
2002	142	-8.78	30.63	23.01	0.32

Difference in the means equals the mean score of end-of-semester exam minus the mean score of the mid-semester exam.

Table 12.4 shows that the boys performed marginally better in 2002 for the Knowledge section of the end-of-semester exam when compared with this section of the exam in 2001. The effect size on the Application results was the same which suggested that web-based learning did not seem to have any influence on this section of the exam. From a teacher's perceptive, an innovation should either maintain standards or improve it. In the case of boys, this appeared to have been achieved to a small extent. How did the boys in each quartile perform? Was there any difference in their performance in the Knowledge and Application on a quartile by quartile basis. The performance of the boys in the four quartiles was initially investigated for the Knowledge section (Table 12.5).

Table 12.5

An Analysis of the Performance of Boys in the Knowledge Section of the Year 10 Science Exam Results obtained in 2001 and 2002.

Quartile	Sample Size (*N*)	Difference in means#	Standard Deviation End-Sem.	Standard Deviation Mid-Sem.	Effect Size
Knowledge Results (Traditional learning group - 2001)					
1	31	- 1.61	5.24	7.20	0.26
2	23	- 9.04**	5.07	8.91	1.25
3	31	- 4.06	4.96	16.98	0.32
4	23	- 19.65**	10.7	18.94	1.28
Knowledge Results (Blended learning group – 2002)					
1	38	7.68**	4.32	12.4	0.83
2	40	5.85*	2.88	17.01	0.48
3	32	5.63	4.45	20.92	0.37
4	32	- 2.75	11.73	22.84	0.15

Difference in the means equals the mean score of end-of-semester exam minus the mean score of the mid-semester exam.
* $p<0.05$. ** $p<0.01$.

Table 12.5 shows some very interesting results. For the boys in 2001, the differences in the means in the end and mid-semester exams were negative and generally increased with the quartiles. These differences showed that the boys did better in the mid-semester than in the end-of-semester exams. The effect sizes varied between the quartiles for the Knowledge results. It ranged from small to large with calculated values of 0.26, 1.25, 0.32, and 1.28 for quartiles one to four respectively. A paired sample t-test showed that the differences in the means were statistically significant for quartiles two ($t\,(22) = 5.41, p<0.01$) and four ($t(22) = 4.65, p<0.01$) with students achieving higher means in the mid-semester than end-of-semester exams.

For the boys in 2002 (Table 12.5), the differences in the means of the end and mid semester exams were positive for the first three quartiles and these differences generally diminished with the quartiles. Quartile four was the only one where the boys did slightly better in the knowledge section of the mid-semester exam in comparison to their results in the end-of-semester exam. The effect size changed from large (d = 0.83) for quartile one to medium for quartiles two (d = 0.48) and small for quartile three (d = 0.37). For quartile four negative difference in the means was associated with a small effect size (d = 0.15). For quartiles one and two, a paired sample t-test showed that the differences were also statistically significant at $p<0.01$ and $p<0.05$ respectively. In comparison to 2001, all groups seemed to have achieved a better result for the Knowledge section of the end-of-semester exam in 2002. Even though the difference in the Knowledge means for the boys in the fourth quartile was negative, the effect sizes suggested that the boys in 2002 (d = 0.15) had done much better than the boys in 2001 (d= 1.28).

Collectively, these results suggest that in comparison to the boys in 2001, the boys performed significantly better in 2002 for the Knowledge section of the exam. A similar analysis was carried out for the Application results of boys in 2001 and 2002 (Table 12.6).

Table 12.6

An Analysis of the Performance of Boys in the Application Section (Based on Quartiles) in Year 10 Science in 2001 and 2002.

Quartile	Sample Size (*N*)	Difference in means	Standard Deviation End Sem.	Standard Deviation Mid Sem.	Effect Size
		Application Results (Traditional learning group – 2001)			
1	31	8.22*	17.64	16.87	0.48
2	23	-11.96	25.4	18.26	0.54
3	31	-7.58	24.95	17.52	0.35
4	23	-13.92*	14.81	18.23	0.84
		Application Results (Blended learning group – 2002)			
1	38	1.31	24.82	14.26	0.06
2	40	-1.26	20.52	22.59	0.06
3	32	-14.54**	23.88	23.92	0.61
4	32	-26.25**	19.71	24.51	1.18

Difference in the means equals the mean score of end-of-semester exam minus the mean score of the mid-semester exam.
* $p<0.05$. ** $p<0.01$.

The difference in the means for the Application section did not show any consistent patterns. In 2001, the positive difference in the mean for the first quartile equated to a medium effect size (d = 0.48). For all other quartiles, the differences in the means were negative and the effect sizes ranged from small to large. In 2002, the difference in the Application means for the first two quartiles were very small. Consequently, the effect size and the difference in the means for the first two quartiles were not statistically significant. A paired sample t-test showed that there was a significant effect for quartile three ($t(31) = 2.84$, $p < 0.01$) and quartile four ($t(31) = 6.70$, $p < 0.01$) with students achieving higher scores in the Application section of the mid-semester than the end-of-semester exams. These differences also coincided with medium to large effect sizes for these two quartiles.

These results show that unlike the Knowledge section, web-based learning appeared to have limited positive influence on the Application section of the exam for the boys. Were these results any different for the girls? This is investigated in the next section.

12.5 PERFORMANCE OF GIRLS

An analysis similar to the one reported in the previous section was performed for the results obtained by the girls. The performance of girls in 2002 (with the blended learning approach) was compared with the results obtained by the girls in 2001 who were taught by the traditional approach. These results are reported in Table 12.6

Table 12.7

Performance of Girls in Year 10 Science Exams in 2001 and 2002.

Year	Sample Size (*N*)	Difference in means#	Standard Deviation (End-of-Sem.)	Standard Deviation (Mid-Sem.)	Effect Size
			Knowledge Results		
2001	108	-7.74	20.78	20.00	0.38
2002	100	-1.66	18.04	19.71	0.09
			Application Results		
2001	108	-5.32	33.60	25.60	0.18
2002	100	-16.15	28.93	22.31	0.63

Difference in the means equals the mean score of end-of-semester exam minus the mean score of the mid-semester exam.

For the girls in 2001, the effect size for the negative difference in the Knowledge means was 0.38. For a similar sample in 2002, the difference in the means was still negative but the effect size was much smaller (d = 0.09). The Application results were of some concern. Unlike the boys where the differences were comparatively the same in both years (see Table 12.4), for the girls in this instance, the effect sizes were 0.18 and 0.63 in 2001 and 2002 respectively. The fact that the girls were worse off than the boys is of some concern. The performance of the girls in each quartile was carried out to determine the group or groups which were most affected. The performance of the girls in the Knowledge section in each quartile is reported in Table 12.8.

Table 12.8

An Analysis of the Performance of Girls in the Knowledge Section (Based on Quartiles) of the Year 10 Science Results in 2001 and 2002.

Quartile	Sample Size (N)	Difference in means	Standard Deviation End Sem.	Standard Deviation Mid Sem.	Effect Size
Knowledge Results (Traditional learning group – 2001)					
1	24	0.25	5.00	5.92	0.05
2	32	-1.13	4.86	15.27	0.10
3	24	1.67	4.93	17.65	0.13
4	31	-10.39**	15.11	20.10	0.58
Knowledge Results (Blended learning group – 2002)					
1	23	10.43*	4.34	21.76	0.66
2	21	1.24	2.53	13.59	0.13
3	29	-6.14*	3.84	14.19	0.59
4	28	-6.50*	11.19	17.57	0.44

Difference in the means equals the mean score of end-of-semester exam minus the mean score of the mid-semester exam.
* $p<0.05$. ** $p<0.01$.

Table 12.8 shows that for the girls, the effect sizes ranged from 0.05 to 0.58 for the difference in the Knowledge means across the four quartiles in 2001. For the first three quartiles, the differences in the means were very small and was not statistically significant. However, a paired sample t-test showed that there was a significant effect for quartile four ($t(30) = 3.20, p < 0.01$), with the girls achieving higher scores in the mid-semester than end-of-semester exams. This was confirmed by a medium effect size ($d = 0.58$).

In 2002, the girls in the first quartile had a mean difference of 10.43 and a paired sample t-test showed there was a significant effect for this quartile ($t(22) = 2.28$, $p<0.05$), with students achieving higher scores in the Knowledge section of the end-semester than the mid-semester exams. This difference equated to a medium effect size of 0.66. The difference of means in the second quartile was smaller. Consequently, the effect size was smaller ($d = 0.13$).

In quartile three, effect sizes of 0.13 and 0.59 were calculated for 2001 and 2002 respectively (Table 12.8). However, the difference in the means in 2002 was negative. Consequently, these results suggested that in 2002, the girls did not do as well as the girls in the third quartile in 2001. In the fourth quartile, effects sizes were comparable with values of 0.44 (2002) and 0.58 (2001), even though there was a slight improvement in 2002. These results suggest girls in the first quartile were the ones who showed significant gains in their Knowledge results in the end-of-semester exams. A similar analysis was performed for the results obtained in the Application section of the exams (Table 12.9).

Table 12.9

An Analysis of the Performance of Girls in the Application Section (Based on Quartiles) of the Year 10 Science Results in 2001 and 2002.

Quartile	Sample Size (*N*)	Difference in means#	Standard Deviation End-Sem.	Standard Deviation Mid-Sem.	Effect Size
Application Results (Traditional learning group - 2001)					
1	24	5.78	17.93	15.41	0.35
2	32	-1.41	30.31	18.49	0.06
3	24	-22.71	16.70	19.54	1.25
4	31	-20.49**	13.99	24.04	1.04
Application Results (Blended learning group - 2002)					
1	23	-0.22	21.69	20.79	0.01
2	21	-6.20	23.64	16.73	0.30
3	29	-19.14**	26.10	21.20	0.80
4	28	-24.82**	16.85	21.90	1.27

Difference in the means equals the mean score of end-of-semester exam minus the mean score of the mid-semester exam.
* $p<0.05$. ** $p<0.01$.

The difference in the means of the Application results in the two exams progressively widened (Table 12.9). These variations corresponded to effect sizes which showed a progressive increase in 2002 with values of 0.01, 0.30, 0.80, and 1.27 for quartiles one, two, three, and four respectively. A similar pattern was observed in 2001 with effect sizes of 0.35, 0.06, 1.25 and 1.04 for quartiles one, two, three, and four respectively. The effect sizes obtained for quartiles two, three, and four were associated with negative differences in the means. The results of quartiles one, two and four suggest that girls in 2001 performed better than the girls in 2002 in the Application section of the exam.

12.6 CHAPTER SUMMARY

In this chapter an analysis of the performance of boys and girls was carried out. It was found that the overall performance of girls in 2001 was generally better than boys in both the Knowledge and Application sections of both the mid and end-of-semester exams. However, in 2002, the girls did better than the boys in both sections of their mid-semester exam but the boys after the blended learning experience reversed this difference in the end-of-semester exams. Even though the boys did better in the end of semester exam, the differences were small and statistically not significant.

A quartile by quartile analysis of the difference in the end and mid-semester results showed that in comparison to the boys in 2001, in 2002 they performed significantly better in the Knowledge section of the exam. However, the blended learning approach had limited influence on the Application means. A similar analysis for the girls showed that at least 25% of the population did better in the Knowledge section in 2002 than in 2001. However, in the Application section, the results were relatively the same.

In Chapter 11, it was shown that the two groups of students were comparable (see Table 11.2). In spite of some variations, the results in this chapter suggest that on an exam by exam basis a blended learning approach did not benefit one group (in terms of their abilities and gender) any more than the other. There was some evidence to suggest that the gap between the results of boys and girls narrowed. Other factors may have also influenced the results. For instance, the teachers were not the same in the two years. Nonetheless, from these results it would be reasonable to suggest that both boys and girls can effectively use a technology-based learning environment and the blended web-based approach was a fair learning medium to both sexes.

CHAPTER 13

CONCLUSIONS

13.1 INTRODUCTION

Hillis (1998) described a computer as not just an advanced machine. He believed that it was an imagination machine that enabled its users to extend their ideas beyond the boundaries which they would have otherwise conquered, on their own. It is widely recognised that many children are more able to use computers than their parents or teachers. Yet in schools, these children were treated like imbeciles and teachers failed to build upon the "kid power" of computers which they possessed (Stager, 2004). Stager argued that by correctly harnessing these skills in technology, teachers can "breathe life into the least effective teaching practices of yore" (Stager, 2004a, para. 12). A common view held by numerous researchers is that technology alone does not make a difference in education; how innovatively it is used by teachers makes the difference (e.g., Downes, 2004; Romeo, 2004; Spender, 2004).

In this study, a teacher (the researcher), with almost no experience in ICT, developed a website (*Getsmart*) for his students in physics and science. The need for such an initiative was directly related to three factors. Firstly, numerous researchers have suggested that there was a need for new approaches to teaching science (e.g., Goodrum, Hackling, & Rennie, 2001). This issue is addressed in this study by using a blended web-based learning approach in science and physics lessons. Secondly, with the increasing availability of ICT in homes and schools, blended web-based learning has become a realistic possibility. Thirdly web-based learning is known to have several advantages such as it tapped into learners' familiar territory, was capable of addressing the needs of many learners, and it was a smart medium (Linnell, 2003). This study had a research and development focus. The impact of such an environment on students' perceptions together with their attitudes and performance in physics and science were also studied. This unique research took a case study approach.

This chapter presents an overview of the study (13.2). The findings associated with each research question proposed in Chapter One are reported (13.3) followed by additional findings (13.4). The implications of this study for teachers are reported in section 13.5. Finally, the limitations of the study are acknowledged together with recommendations for future research.

13.2 OVERVIEW OF THE STUDY

This thesis consisted of eleven chapters which were divided into five main sections; Introduction, Literature Review, Methodology, Results and Discussion, and Conclusion. The study focussed on three key areas; Learning Environments, Technology in Education, and Science Education. Consequently, Chapters Two, Three, and Four presented a review of the literature in these three areas.

A review of the literature in Chapter Two examined the evolution of the field of learning environments. The development and use of learning environment instruments in classrooms was also presented. References were made to several studies whose findings were relevant to this research. For example, Lorsbach and Basolo (1998) reported that students perceived science as a body of facts that had to be learned and experimentation was viewed as a case of regurgitating what others had already found out. Other studies like this presented a case for varying classroom routines in order to re-engage learners. While well-planned variations to routines often led to desirable outcomes (e.g., Hofstein, Nahum, & Shore, 2001; Hofstein, Kesner, & Ben-Zvi, 1999), poorly structured approaches in which learners confronted unfamiliar environments had the potential to create a negative impact (Elen & Clarebout, 2001). Several studies showed that the use of technology in the classroom had a positive effect on students (e.g., Aldridge & Fraser, 2003; Khine, 2003; Saarenkunnas, Järvelä, Häkkinen, Kuure, Taalas, & Kunelius, 2000; She & Fisher, 2003). Gräsel, Fischer, and Mandl (2000, p. 302) concluded that even with advanced learners, "instructional designers cannot rely on learners recognizing and correcting their mistakes when learning individually". Findings such as these supported a case for a blended approach to web-based learning.

In Chapter Three, some of the current issues in the teaching and learning debate were highlighted. The successes and failures of numerous technologies in addressing some of these issues also were presented. The views of certain critics (e.g., Oppenheimer, 1997) on the use of technology in education were outlined. A case for using the Internet in teaching and learning was presented based on 11 reasons. A number of issues raised in the chapter were addressed in this study. Firstly, in several studies (e.g., Churach, 1999; Eklund, Kay, & Lynch, 2003), the lack of teacher in-service had been blamed as one of reasons why the Internet was not widely used in teaching. This study aimed to demonstrate that teacher motivation, innovativeness, and aptitude were probably equally if not more important than teacher in-service when using new technologies. Secondly, there was considerable debate on the design and implementation of web-based lessons (Janicki & Liegle, 2001) and it was decided that in this study, a cognitive apprenticeship-teaching model would underpin the design of *Getsmart*. Thirdly, the study was conducted in a full-time high school setting where a blended learning approach was a realistic possibility. Such an approach promoted appropriate, and sometimes multiple-learning styles, in one subject (Valiathan, 2002) by using the best of traditional and technology-enhanced delivery methods (Zenger & Uehlein, 2001). It also enabled teachers to act as facilitators (Eklund, Kay, & Lynch, 2003).

Chapter Four highlighted a number of important issues that were relevant to science education. It was pointed out that despite the increasing availability of ICT in schools, 67% of the students had never used computers in their schoolwork and 54% had never looked for information on the Internet at school (Goodrum, Hackling, & Rennie, 2001). Goodrum, Hackling, and Rennie also pointed out that teaching and learning methods in science are dominated by traditional methods such as chalk and talk teaching, copying notes off the board and cookbook type practical lessons which offered little challenge or induced any excitement in the lessons. One third of the respondents never received any feedback from their teachers on how they were going in science. They also indicated that while enrolments in science in post compulsory years of schooling had dropped, the gap in the academic performance of boys and girls had also widened. These findings suggested that there was an obvious need to design and develop student friendly teaching methods in order reinvigorate student interest in these subjects.

The Web-based Learning Environment Instrument (WEBLEI) (Chang & Fisher, 2003) was used for gathering quantitative data on students' perceptions of their learning environment. In Chapter Five, the design and development of the WEBLEI was presented and the use of the modified version of the WEBLEI in this study was outlined. In Chapter Six the methodology used in this research was explained and the development and design of *Getsmart* described. The steps in the implementation of web-based lessons in a blended environment were also presented. The samples used in this study together with other relevant considerations were detailed. Data collection and analysis methods used in this research were also described in this chapter.

Quantitative and qualitative results of students' perceptions of a web-based learning environment were presented and discussed in Chapters Seven and Eight respectively. In Chapter Seven, the reliability and validity statistics of the WEBLEI were presented followed by an analysis of students' responses to the WEBLEI. This investigation was carried out on the basis of subjects (physics or science), year levels, teachers, and gender. Where possible, a comparison was also carried out between the results obtained in 2002 and 2003. In Chapter Eight, qualitative data gathered from emails, written surveys, and chats were presented. This chapter also provided supporting evidence to the quantitative data presented in Chapter Seven. The chapter concluded with a suggestion that the WEBLEI should include an additional scale that ascertained students' perceptions of their interaction with technology.

In Chapter Nine, qualitative and quantitative results associated with the impact of a web-based learning environment on students' attitudes were presented and discussed. The qualitative evidence was generated through an attitude to science survey that was created on basis of evidence provided by Goodrum, Hackling, and Rennie (2001). Associations between the WEBLEI scales and the attitude to science scale were also determined. This chapter also provided qualitative evidence gathered through written surveys and it was noted that this supported the findings generated by the quantitative data. The chapter finished off by presenting further evidence that student behaviour in terms of the use of the website and their assessment of the lessons through the online survey suggested that students had positive attitudes towards such an environment.

Chapters Ten and Eleven focussed on the impact of a web-based learning environment on students' learning outcomes in senior physics and junior science respectively. Qualitative data obtained from written surveys were presented in each case. As in other chapters, evidence generated from quantitative data was used to support the evidence gathered through qualitative methods. In both these subjects, it was evident that web-based learning did affect students' learning outcomes in certain performance domains. In Chapter Twelve, the performance of boys and girls in junior science was analysed. Based on this analysis it was concluded that there was some evidence to suggest that the gap between the results of boys and girls narrowed as a result of the web-based approach but on the whole it did not seem to advantage one group any more than the other. It was also suggested that both boys and girls can effectively use a technology-rich learning environment and the blended web-based approach was a fair learning medium to both sexes.

13.3 MAJOR FINDINGS OF THE STUDY

The first question proposed for this study was:

> *Is the modified version of the Web-based Learning Environment Instrument (WEBLEI) a valid and reliable instrument for use in junior science and senior physics classes?*

The validity and reliability of the WEBLEI was determined through three statistical measures – Cronbach alpha reliability, discriminant validity, and ANOVA scores. The Cronbach alpha reliability coefficient measures the internal consistency of an instrument and is based on the average inter-item correlation. As reported in Chapter Seven, the alpha reliability coefficient for the scales of the WEBLEI ranged from 0.78 to 0.86. In this study, the values of the alpha reliability coefficients were higher than those reported by Chang and Fisher (2003) who administered the WEBLEI to off-campus tertiary students. All values above 0.60 obtained through this calculation are considered to be acceptable (Nunnally, 1967). Consequently, for the purposes of this research, the modified version of the WEBLEI was a reliable instrument.

The discriminant validity measures the extent to which a scale measures a unique dimension not covered by other scales in the instrument. The discriminant validity obtained for the scales of the WEBLEI ranged from 0.52 to 0.59. In the study by Chang and Fisher (1998), the discriminant validity ranged from 0.37 to 0.49 which suggests that in both studies, the WEBLEI measured distinct, yet some overlapping aspects of the learning environment.

An ANOVA compares the means for different groups. The Eta^2 statistic is the proportion of variance in the dependent variable that is explained by the independent variable. It is also an indication of how well an instrument is able to measure the difference between classes (Nair & Fisher, 1999). In this instance, the difference between the means of the classes was significant for the Interaction ($p<0.01$), Response ($p<0.05$), and Results ($p<0.01$) scales. Overall, on all these results, it can be concluded that WEBLEI was a valid and reliable instrument for this study.

The second research question proposed in this study was:

> *What are student perceptions of their web-based learning environment?*
> *Why do students have these perceptions?*

The WEBLEI was designed to determine student perceptions across four scales – Access, Interaction, Response, and Results. Data from the WEBLEI survey were coded and entered as 1 (*Strongly Disagree*), 2 (*Disagree*), 3 (*Neither Agree nor Disagree*), 4 (*Agree*), and 5 (*Strongly Agree*). Student responses to the WEBLEI suggested that *Getsmart* and web-based learning was efficient and offered them convenience and autonomy (Chapter Seven). This was because the overall mean for the Access scale was 4.02 (SD = 0.59) which suggested a high level of agreement with the characteristics of this scale. Students agreed to varying degrees that such an approach to learning enhanced interaction with the teachers and other students. The mean for the Interaction scale was 3.53 (SD = 0.71). Many students in this sample did not feel comfortable sending emails to their teachers. Such an attitude could have influenced the results of this scale because four out of the eight items in this scale dealt with emails. Qualitative data suggested that there was greater student interaction with the Internet technology rather than with other participants.

The respondents agreed generally with the items of the Response scale. For this scale, an overall mean of 3.81 (*SD* = 0.67) was obtained. These values suggested that the students enjoyed learning via the Internet because it was interesting and more satisfying. The four scales of the WEBLEI are interconnected with each other in an orderly sequence, for example, the Results scale relies on the other three (in order) and shows whether the students have accomplished any learning objectives through a web-based learning environment (Chang & Fisher, 1998). For this scale, a mean of 3.98 (*SD* = 0.58) was obtained which suggested that in this case students believed that web-based learning had enhanced their learning outcomes.

The mean scores across the four WEBLEI scales were very close to four which suggested that students generally agreed with the items in all scales. This was also reflected in the data gathered qualitatively (Chapter Eight). Interestingly the emails and the answers to open-ended survey questions suggested that there was a strong connection between students' perceptions of a web-based learning environment and the characteristic of the four scales of the WEBLEI. These responses gave an insight into the reasons for their positive perceptions. Students believed that flexibility, accessibility after school, learning at their own pace were significant aspects of such an approach. These were significant aspects of the Access scale. Student responses also supported the attributes of the Interaction scale believing that their ability to interact through chats not only kept them focussed but reinforced what they had learnt in class. Their ability to question their learning through emails was also evident. Suggestions of how the teaching medium could be improved, by enabling them to be more actively involved in their learning, were also made.

Qualitative data also provided support for the relatively high mean on the Response scale. Students indicated their belief that web-based learning was interesting, fun, made learning easier, was less stressful and was not as boring as being in the traditional classroom. They also believed that the web-based lessons were well structured and kept them on task. Students felt that this approach created variety in their learning and varied their routines which in turn created new opportunities. Numerous responses also provided support to the features of the Results scale. Students pointed out that web lessons were simplified, helpful, easier to understand, had learner friendly graphics, and self-testing quizzes which collectively made learning easier and contributed positively to their learning outcomes.

The third research question proposed in this study was:

> *Is there any difference in students' perceptions according to subjects, gender, teachers, and academic ability groups?*

Eklund, Kay, and Lynch (2003) suggested that there was some evidence that the role of a teacher was far more important than the instructional design of the online content. Additionally, how teachers market and apply appropriate teaching pedagogies in such an environment may be crucial in influencing students' perceptions. In 2002, the researcher had four out of the eleven classes that were involved in this project. The combined means across all four of the researcher's classes were compared with those of the other teachers (Chapter Seven). It was found that there was a significant effect for the Interaction ($p<0.01$) and the Results ($p<0.05$) scales, with students in the researcher's classes scoring higher means than students in other classes. A similar difference was also found for the Response scale. However, this difference was not statistically significant. These results suggested that the role of teachers in such an environment might be an important factor in influencing student perceptions.

The investigation was extended to the researcher's four classes to see the extent to which the means across the four scales varied in these classes. The variation between the class means showed that even though students had the same teacher and they were all taught the same way, there was probably a limit in terms of how much a teacher could influence students' perceptions of their learning environments.

Further analysis showed that students in senior physics had more positive perceptions than students in junior science. These differences were significant for the Access ($p<0.01$), Interaction ($p<0.01$), and Results ($p<0.05$) scales. The difference in these means was probably because physics students were more motivated than students are in junior science classes. Consequently, they perceived their learning environments more positively than did those students in junior science classes. Waxman and Huang (1998) also reported that students in the middle school perceived their learning environments less favourably than those in elementary and high schools.

The variations in students' perceptions in junior science and senior physics were also observed when the WEBLEI data were analysed according to gender. The results showed that overall there was no difference in the perceptions of boys and girls of a web-based learning environment. However, boys and girls in physics had more positive perceptions than boys and girls in junior science classes. These results once again suggested that boys and girls in physics generally had more positive perceptions because they were more motivated, chose physics because they wanted to, and they were probably more mature then their junior science counterparts. Consequently, they were more likely to grab educational opportunities that had the potential to enhance their learning outcomes.

An analysis of the WEBLEI data based on academic ability was interesting. All students regardless of how they performed in their school exams at the end of their web-based learning experience appeared to have similar perceptions of their learning environment. For this analysis, students were divided into quartiles (based on their exam results) and their WEBLEI responses were analysed on this basis. The means across the four scales were approximately the same for each quartile which suggested that irrespective of their academic abilities, students had similar perceptions of such an environment. It was interesting to note that students in the fourth quartile (students who scored less than 47% in the exam) obtained means which compared favourably with other quartiles across all four scales. They achieved marginally higher means for the Access and Results scales than did the rest of the group. These results showed that web-based learning was not just for the academically gifted or the computer "nerds".

The fourth research question proposed in this study was:

> *What are student attitudes to junior science and senior physics? Do students' attitudes to their subjects change after they have experienced web-based learning? Why do students attitudes change?*

The impact of a blended web-based learning approach was investigated in this study. It was hoped that such an innovative approach, coupled with traditional classroom routines, would produce variety and flexibility in lessons using technology. In this research, it was believed that if students had positive perceptions of a blended web-based learning environment, then it also had the potential to impact on their attitudes to science.

Goodrum, Hackling, and Rennie (2001) produced a comprehensive report titled *The Status and Quality of Teaching and Learning of Science in Australian Schools* on issues that related to science education in Australia. Some of the issues raised by Goodrum, Hackling, and Rennie (2001) formed the basis of an *Attitudes to Science* survey in this study. This survey consisted of seven items and was administered to students before and after they had participated in the web-based approach.

The Cronbach alpha coefficient for the Attitude to Science scale was found to be 0.85 The closer the alpha coefficient is to 1.0, the greater the internal consistency of the items in the scale. George and Mallery (2003) believed that an alpha coefficient of 0.8 to 0.9 is good. Consequently, in this case, the internal consistency of items of this scale was good. This survey was administered to students before and after they experienced web-based learning. In both instances, the means were close to three, which suggested that overall the students neither agreed nor disagreed with the items. However, the mean obtained after the students had participated in web-based learning was higher and a paired sample t-test showed that this difference was statistically significant ($p<0.01$). The difference in the means had an effect size of

0.33. Cohen (1988) interpreted an effect size of 0.2 as small and 0.5 as medium. Both these statistical tests suggested that web-based learning did improve students' attitudes towards their subjects.

Qualitative data gathered from the sample provided further support to the quantitative data. In junior science, in excess of 85% and in physics, more than 70% of the students believed that web-based learning made their subject more interesting. Students gave different reasons, such as web-based learning added variety to their lessons, it made learning easier and more effective, online tests gave instant results, online chats kept them on task and so on. In Chapter Nine students' reasons were presented in detail and based on these, it can be suggested that students neither agreed nor disagreed with the seven items of the attitude scale (see Section 9.2), however, their attitudes to their subjects improved once they had experienced web-based learning.

The fifth research question proposed in this study was:

> *Do students think that the web-based learning approach improves their understanding in science or physics?*

Qualitative data from the physics students showed that between 70 and 80% believed that web-based learning did improve their understanding in the subject. Similarly, more than 70% of the students in the junior science classes held a similar view. Students gave a variety of reasons such as the content in the web-lessons were concise which made learning easier, online tests provided practice and challenge, after-school chats clarified difficulties, worked examples enhanced their understanding, blended learning improved student results because it catered for different learning styles, and so on.

Data gathered online provided further evidence in terms of students' confidence in such an approach to learning (see Section 9.4). Login data suggested that 87% of the group in 2003 logged in at least once on the website. On average, students logged in 14 times. The number of logins per student ranged from 1 to 106 over a seven-month period. Of the 1,683 student logins over this period, 62% of these occurred in the students' own time outside scheduled lessons (e.g. lunch breaks, after school in the afternoons, evenings, weekends and public holidays). Students' login frequencies after school were most significant. Most students actively used the website after 4.30 pm and until 11.30 pm. For 20 hours a day, the website had at least one or more users logged in. It was also interesting to note that even after students had completed their unit of work taught online, some continued to access *Getsmart*. The students did so because they believed that the website had some well-structured lessons that were related to their other units of work.

At the end of each web-lesson, students were asked to rate their lessons and were given five options. More than half (60%) of the students rated the lessons as either *very good* or *excellent*. One quarter of the group believed that the lessons were average and one-tenth of this sample thought that the lessons needed improvement. It was also interesting to note that only five-percent felt that these lessons were a waste of time which suggests that for the majority of the students, such an approach was perceived to be valuable in terms of their learning. Students' qualitative responses and their use of the website suggested that they did have a belief that such an approach influenced positively on their learning.

The sixth research question proposed in this study was:

> *Do exam results in physics suggest that student academic outcomes are influenced by a web-based learning approach?*

The physics sample was relatively small and the analysis focussed primarily on the performance of four groups of students before and after web-based learning. Three physics groups in 2002 and 2003 (Groups A, B, and C) used *Getsmart* in a blended learning environment. The group in 2001 (Group D), was taught through traditional methods. Consequently, the results obtained by students in this group were conveniently compared to the exam results of students who had experienced web-based learning. Such comparisons have to viewed with caution because the students in the four groups were different.

Students in senior physics in Queensland schools are assessed in three areas; Knowledge, Science Processes, and Complex Reasoning Skills. The Knowledge section of the assessment examines students' abilities to recall and apply their understanding to simple situations. Science Processes measure their abilities to collect, present, and interpret data. The Complex Reasoning Skills section measures their ability to apply themselves in problem solving situations. Assessments are predominantly based on written exams that are done at the end of each term. There was also a practical exam each semester. The senior physics course runs over two years.

When students' before and after web-based learning exam results were compared it was found that the results in the Knowledge section of the exams improved for all three groups (Groups A, B, and C) after web-based learning. The differences in the means were statistically significant at $p<0.01$ (Group A) and $p<0.05$ (Groups B and C). These differences also corresponded to medium to large effect sizes. The means of the two exams results of the control group (Group D) was almost the same (see section 10.3.2). Comparatively, no such observations were made when the Science Processes results were compared (see section 10.3.3). The results in the Complex Reasoning section of the exams were interesting. The means for all four groups declined. Consequently, the magnitudes of the effect sizes for the three groups that participated in web-based were much smaller than Group D (the control group) (see section 10.3.4). These results suggested that web-based learning probably did help students achieve better results in this section. Evidence that supported this reasoning was the high effect sizes obtained for the Knowledge results for Groups A, B, and C which suggested that students had demonstrated a good knowledge and understanding of this topic. Consequently, since they had good understanding, they were able to demonstrate this in unseen situations (feature of Complex Reasoning assessment items) which appeared to be the case in this instance.

On the basis of the overall performance (i.e. combined results for the Knowledge, Science Processes, and Complex Reasoning sections) medium effect sizes for Groups A, B, and C were found. On the other hand, an effect size of 0.05 was calculated for Group D whose overall mean declined (see section 10.3.4). These results suggest that web-based learning did improve students' overall performance even though some of the variations may be due to different students, with different learner characteristics. In response to Research Question Five, it was pointed out that qualitative data gathered from students suggested that there was an overwhelming belief that web-based learning did influence their learning outcomes. The analysis of exam results presented in this case provided further evidence that a blended web-based learning environment had a positive influence on students' learning outcomes in physics.

The seventh research question proposed in this study was:

> *Do exam results in junior science suggest that student academic outcomes are influenced by a web-based learning approach?*

Qualitative responses from students and quantitative data gathered online (Research Question Five) demonstrated that a vast majority of the sample believed that the blended learning approach did influence their learning outcomes. The frequency of use demonstrated that there was a belief amongst the students that the website was beneficial to them.

Students in junior science were introduced the web-based learning and taught in a blended environment for one term. The exam results of these students were compared in two ways. Firstly, the results of this group were compared with the group in 2001. The group in 2001 was taught via traditional methods. For reasons explained in Chapter 11, the results in two out of the three sections of the assessments were compared - Knowledge and Application. The analysis showed that in comparison to the results obtained in 2001, the students in 2002 did significantly better in the Knowledge section of their end-of-semester exams after experiencing web-based learning. No difference was found in the Application results. As pointed out earlier, when making such comparisons, it has to be borne in mind that the two groups had different students.

Secondly, when the results obtained in the mid and end-of-semester exams were compared on a year by year basis, it was found that with the blended learning group, there was no difference in the Knowledge results but the Application results declined. Comparatively, for the group in 2001, results in both Knowledge and Application section had declined (see section 11.3.1). Based on these comparisons it can be suggested that the web-based learning approach probably influenced positively on the Knowledge results but had no impact on the Application results.

Further analysis of the results based on their performance in quartiles showed that in comparison to similar quartiles in 2001, students in quartiles one and two in 2002, did better in both sections of the exam. A similar comparison with the students in 2001 showed that the performance of students in quartile three was almost the same whereas in quartile four students did significantly better in the Knowledge section but did not do as well in the Application section. Based on these results, it can be suggested the web-based approach probably improved Knowledge results for at least 75% of the sample and Application results improved for the top 50% of the group.

The Knowledge section of the tests examined students' abilities to recall and apply their understanding to simple situations. The Application section measured their abilities to apply themselves in problem solving situations. These results imply that for most students, web-based learning enhanced their abilities to recall and apply their knowledge in simple situations. On the other hand, only the more able students in junior science classes were able to apply the knowledge gained through web-based learning in problem solving situations.

The eighth research question proposed in this study was:

Is there any difference in academic achievement according to gender?

An analysis was carried out on the performance of boys and girls in junior science in 2001 and 2002. No such analysis was possible with the physics group due to the small sample size. It was found that the overall performance of girls in 2001 was generally better than boys in both the Knowledge and Application sections in both exams (see Chapter 12). In 2002, the girls did better than boys in both sections of their mid-semester exams but the boys after the blended learning experience reversed this difference in the end of semester exams. This suggested that suggest that the gap between the results of boys and girls may have narrowed because of the web-based approach. Even though the boys did better in this exam, the differences were small and statistically not significant. Further analysis of the differences in the performances of boys and girls in the different quartiles led to the conclusion that on an exam by exam basis, a blended learning approach did not benefit one group (in terms of their abilities and gender) any more than the other. Consequently, the web-based approach was a fair learning medium for both sexes.

13.4 ADDITIONAL FINDINGS

This study also produced a number of other findings. Firstly, Moos (1974) suggested that participants usually perceived their actual setting less favourably than the preferred setting. In this research, the finding was consistent with Moos's observation. The WEBLEI data suggested that students' preferred a more positive learning environment than that actually perceived.

Secondly, a group of physics students were administered with the WEBLEI twice more than a year apart in Year 11 and in Year 12. It was found that despite improvements to the website, the perceptions declined marginally. However, the decline in the performance was not statistically significant (see section 7.4.1). It was interesting to note that overall, the perceptions changed little over this period.

Thirdly, the means across three of the four WEBLEI scales were almost the same (Chapter 7). However, the mean for the Interaction scale was comparatively low and students' qualitative responses suggested that in a blended based learning environment, the interaction between students' and technology was considered more important than the interaction between the teaching and learning community through technology. The Interaction scale of the WEBLEI measures the latter rather than the former. Probably the interaction between the learners and the technology (rather than interaction between learners and educators) led to a significantly higher mean for the Results scale. Otherwise, given the rationale of the design of the WEBLEI, these results may not have been obtained. On the basis of these results, it was proposed (see section 8.5) that another scale should be added to the WEBLEI in order to specifically measure the perceptions of the learners as they interacted with technology in an online learning environment.

13.5 IMPLICATIONS FOR TEACHERS

This study has demonstrated teachers can perform the role of web-developers and design websites. More importantly, such an initiative not only influenced students' perceptions, but it also had a positive impact on their attitudes and performance in their subjects. Collectively, these conclusions support a positive case for the assimilation of the Internet in not only high school science, but other subjects as well.

In his research with high school science students in Hawaii, Churach (1999) concluded that the Internet did have an impact on their learning "even though they may have spent a great deal of time tinkering with their terminals" (p.117). Churach's observations supports the notion of discovery learning with the aid of the Internet. While this is a possibility, it has to be borne in mind that there is an ever-increasing number of websites and webpages that are uploaded to the worldwide web. When a search was conducted on *Google* (www.google.com) for the word *Atom,* the search engine produced 10,400,000 hits. A month later, there were 11,100,000 hits. For students engaged in blended learning, time is a vital factor. Searching and sieving through a mountain of websites can be an onerous task which can easily turn students' enthusiasm to boredom and mischief. The Internet is a powerful tool and teachers have to find novel methods of using this tool so that it enhances the efficiency of the learning process and keeps the learners focussed.

One such method hypothesized in this study was the use of *Getsmart,* a teacher-developed website that was tailored to the needs of the learners. Rickards (2003) pointed out that future education success did not depend upon the latest or the fastest technology but rather on the effective use of whatever technology is readily available. Rickards thoughts mirrored the famous quote of American President Theodore Roosevelt "Do what you can, with what you have, where you are." Lack of teacher in-service has often been used as a reason to justify the lack of use of technology in classrooms. This study has shown that a teacher with almost no in-service or expertise in ICT can effectively use the existing technology to deliver productive programs to the students. *Getsmart* in this instance serves as a model for using the Internet effectively. It also shows how some existing issues in science education can be effectively addressed.

Naidu, Cunnington, and Jasen (2002) believed that in terms of ICT, there was a lack of reliable knowledge in terms of what works, why, and in what ways. This study has extended the knowledge on what works, why and in what ways. Jauncey (2004) challenged the rationale for repeatedly using teaching methods which teachers knew were not working. He argued that when embedding new teaching pedagogies in their classrooms, teachers should be very clear in terms of what they were doing, how they were going to do it, did they have the resources, and did they want to do it. This study has addressed the first two aspects of Jauncey's concerns. It has shown what teachers can do with technology and how it can be applied in their teaching routines. Collectively, the issues that were addressed in this study have the potential to give teachers a greater confidence in using technology to vary classroom routines. There is no need for any mammoth changes. Any small change in the classroom routine has the potential to improve existing practice in science education that appears to be dominated by chalk and talk teaching, copying notes of the board, and cookbook type practical lessons, which have switched off students from their subjects (Goodrum, Hackling, & Rennie, 2001).

One of the most significant implications of this study is perhaps that this innovative approach was well received by the students. This approach can be applied to other subject areas as well. It also makes way for further innovation in using technology in education.

13.6 LIMITATIONS OF THE STUDY

The impact of a web-based learning environment was dependent on *Getsmart* which was a teacher-designed website. Consequently, the findings of this study are dependent on the design and effectiveness of the website. It cannot be extrapolated to all educational websites on the Internet.

The research was conducted as a case study at a state high school in Queensland (Australia) where the researcher was a teacher. In this role, the researcher organised the teachers in computer rooms, responded to all questions and emails, designed and developed the website, and provided the leadership that was necessary for the successful implementation of the initiative. Subsequently, such a program may not succeed at another school unless these characteristics are readily available within the staff.

The sample size was an issue in this study. For the collection and interpretation of the qualitative data, a larger sample size in physics would have been ideal. However, given the enrolments at the school where the research was conducted, this was not possible. Additionally, web-based learning was blended in the traditional classroom routine for 17% to 25% of the time for the duration of a term. Variations to the percentage of blending may also influence results.

Numerous comparisons were made between groups of students in this study. These comparisons have to be viewed with caution because there could have been variations in learner characteristics (e.g., preference for learning styles, cultural, and home backgrounds of students) that may have ultimately influenced the results.

13.7 FUTURE RESEARCH

This research has probably just touched the tip of the iceberg in terms of the use of Internet technology in science education. Using proven methods that have been successfully used in learning environment research, the success of an innovative approach to teaching junior science and physics in high schools has been demonstrated. Furthermore, the study has paved the way for further research and development of web-based learning in several ways.

Firstly, the approach should be attempted across several schools and with a larger sample. Such an approach would enable further investigation of the use of the WEBLEI. For instance, with a larger sample size, a factor analysis of the WEBLEI could be more reliably carried out. Similarly, the *Attitude to Science* survey should be validated with a larger sample.

Secondly, web-based learning in science needs to create more opportunities for hands on data analysis approach. In this study, it was shown that students' performance in the Science Processes section of the physics exam was unaffected by such an approach (see Chapter 10). Similarly, in junior science, the results in the Application section was unaffected by this initiative. These results suggest that web-based learning should incorporate a problem solving approach to learning (Jonassen, 2004). A possible approach could be to incorporate online activities with data logging options (e.g., *Lego* robotics) in web-lessons. Such an approach could be added to the existing features of *Getsmart*.

Finally, Dierker (1995) pointed out that technological advancements in the past decade have created teaching and learning opportunities of significant proportions, which would have been a fantasy a few years ago. More importantly, the pace of advancement in Internet technology in the past few years signals a future of unimaginable potential for web-based learning and for websites such as *Getsmart*. Harrison (as cited in Roberts, 2002, p. C13) pointed out that science "was in danger of becoming an optional snack in a smorgasbord of subjects". The Internet offers optimism and with continued research and development of new technologies, science teachers can make science a lucrative option in a smorgasbord of subjects.

13.8 FINAL COMMENTS

This study has shown that:

- ✓ The modified version of the WEBLEI is a valid and reliable instrument for use in junior science and physics.
- ✓ Students have positive perceptions of their blended web-based learning environment.
- ✓ Students in senior physics have more positive perceptions of their learning environment than students in junior science.
- ✓ There was no difference in the perceptions of boys and girls of their blended web-based learning environment.

- ✓ Teachers appeared to influence student perceptions, but it was also found that even with the same teacher and with a consistent teaching approach, student perceptions varied.
- ✓ Students' perceptions were not influenced by academic ability.
- ✓ Students' attitudes towards their subjects improved because of web-based learning.
- ✓ Students believed that such an approach improved their performance in their subjects and the results in some sections of junior science and senior physics exams improved after the students experienced web-based learning.
- ✓ Web-based learning was a fair environment to both sexes.

The comments of a year 10 student probably sum up the impact of web-based learning on the learners...*I found that using the online learning technique was of great benefit to me when studying the topics incorporated in Advanced Science. Learning online enables the student to work at their own pace and in their preferred environment. I believe this allows students to attain and remain in a state of mind that enables a better understanding of the course material. This is also achieved using multimedia in the form of pictures, short animations, and interactive tasks. Students are also able to find out their progress and general understanding of the topics by taking online examinations that give results and feedback. In my opinion, the online course taken by the Year 10 Advanced Science class was highly beneficial to them and their results.*

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APPENDIX A

Items of the WEBLEI & the Modified Version of the WEBLEI.

Items of the WEBLEI & the modified version of the WEBLEI.

Scales/Items of the WEBLEI	Scales/Items of the modified version of the WEBLEI
Scale I: Access	**Scale I: Access**
1. I can access the learning activities at times convenient to me.	1. I can access lessons on the Internet at times convenient to me.
2. The on-line material is available at locations suitable for me.	2. Lessons on the Internet are available at locations suitable for me.
3. I can use time saved in travelling and on campus class attendance for study and other commitments.	3. I can access lessons on the Internet on days when I am not in class or absent from school.
4. I am allowed to work at my own pace to achieve learning objectives.	4. Lessons on the Internet allow me to work at my own pace to achieve learning objectives.
5. I decide how much I want to learn in a given period.	5. Lessons on the internet enable me to decide how much I want to learn in a given period.
6. I decide when I want to learn.	6. Lessons on the Internet enable me to decide when I want to learn.
7. The flexibility allows me to meet my learning goals.	7. The flexibility of lessons on the Internet allows me to meet my learning goals.
8. The flexibility allows me to explore my own areas of interest.	8. The flexibility of the lessons on the Internet allows me to explore my own areas of interest.
Scale II: Access	**Scale II: Access**
1. I communicate with other students in this subject electronically (email, bulletin boards, chat line).	1. I communicate with my teacher in this subject electronically via email.
2. In this learning environment, I have to be self-disciplined in order to learn.	2. In this learning environment, I have to be self-disciplined in order to learn.
3. I have the autonomy to ask my tutor what I do not understand.	3. I have the option to ask my teacher what I do not understand by sending an email.
4. I have the autonomy to ask other students what I do not understand.	4. I feel comfortable asking my teacher questions via an email.
5. Other students respond promptly to my queries.	5. The teacher responds to my emails.
6. I regularly participate in self-evaluations.	6. I can ask other students what I do not understand during computer lessons.
7. I regularly participate in peer-evaluations.	7. Other students respond positively to questions in relation to Internet lessons.
8. I was supported by positive attitude from my peers.	8. I was encouraged by the positive attitude of my friends towards the Internet lessons.

Scale III – Interaction	**Scale III – Interaction**
1. This mode of learning enables me to interact with other students and the tutor asynchronously.	1. This mode of learning enables me to interact with other students and my teacher.
2. I felt a sense of satisfaction and achievement about this learning environment.	2. I felt a sense of satisfaction and achievement about this learning environment.
3. I enjoy learning in this environment.	3. I enjoy learning in this environment.
4. I could learn more in this environment.	4. I could learn more in this environment.
5. It is easy to organise a group for a project.	5. I can easily get students to work with me on the Internet.
6. It is easy to work collaboratively with other students involved in a group project.	6. It is easy to work with other students and discuss the content of the lessons.
7. The web-based learning environment held my interest throughout my course of study.	7. The web-based learning environment held my interest in this subject throughout this term.
8. I felt a sense of boredom towards the end of my course of study.	8. I felt a sense of boredom in this subject towards end of this term.

Scale IV – Results	**Scale IV – Results**
1. The scope or learning objectives are clearly stated in each lesson.	1. I can work out exactly what each lesson on the Internet is about.
2. The organisation of each lesson is easy to follow.	2. The organisation of each lesson on the Internet is easy to follow.
3. The structure keeps me focused on what is to be learned.	3. The structure of the lessons on the Internet keeps me focused on what is to be learned.
4. Expectations of assignments are clearly stated in my unit.	4. Internet lessons helped me better understand the work that was taught in class.
5. Activities are planned carefully.	5. Lessons on the Internet are well sequenced.
6. The subject content is appropriate for delivery on the Web.	6. The subject content is appropriate for delivery on the Internet.
7. The presentation of the subject content is clear.	7. The presentation of the subject content is clear.
8. The quiz in the web-based materials enhances my learning process.	8. The multiple choice test at the end of each lesson on the Internet improves my learning in this subject.

APPENDIX B

The WEBLEI and the Written Survey.

Web-based Learning Environment Instrument#
(#modified version of WEBLEI)

The purpose of this questionnaire is to gather your views on Internet enabled learning or e-learning. A series of statements are given and you have to respond to each in a manner which best sums up your views about learning on the Internet. **There is no right or wrong answers. You will respond to questions as they relate to your actual and preferred learning practices.** This will be explained to you prior to the survey.

Think about each statement, and then draw a circle around:

1. If you **STRONGLY AGREE** with the statement.
2. If you **AGREE** with the statement.
3. If you **NEITHER AGREE DISAGREE** with the statement.
4. If you **DISAGREE** with the statement.
5. If you **STRONGLY DISAGREE** with the statement.

Be sure to respond to all the statements. If you change your mind about an answer, just cross it out and circle another. Some statements may look similar to other statements. Do not worry about this, simply give your opinion about all the statements.

EXAMPLE

Suppose you read the statement "I can access lessons on the Internet on days when I am not in class or absent from school." you will have to decide if you **"STRONGLY AGREE", "AGREE", "NEITHER AGREE NOR DISAGREE", "DISAGREE"** or **"STRONGLY DISAGREE"** with the statement. If you "neither agree nor disagree", then you would circle 3 on your questionnaire.

Your Name ______________________________
Form Class ______________ Male/Female (Circle)
Subject ______________

Thank you for participating in this survey.

	STATEMENTS	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly Agree
1.	I can access lessons on the Internet at times convenient to me.	1	2	3	4	5
2.	Lessons on the Internet are available at locations suitable for me.	1	2	3	4	5
3.	I can access lessons on the Internet on days when I am not in class or absent from school.	1	2	3	4	5
4.	Lessons on the Internet allow me to work at my own pace to achieve learning objectives.	1	2	3	4	5
5.	Lessons on the internet enable me to decide how much I want to learn in a given period.	1	2	3	4	5
6.	Lessons on the Internet enable me to decide when I want to learn.	1	2	3	4	5
7.	The flexibility of lessons on the Internet allows me to meet my learning goals.	1	2	3	4	5
8.	The flexibility of the lessons on the Internet allows me to explore my own areas of interest.	1	2	3	4	5
9.	I communicate with my teacher in this subject electronically via email.	1	2	3	4	5
10.	In this learning environment, I have to be self-disciplined in order to learn.	1	2	3	4	5
11.	I have the option to ask my teacher what I do not understand by sending an email.	1	2	3	4	5

	STATEMENTS	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
12.	I feel comfortable asking my teacher questions via an email.	1	2	3	4	5
13.	The teacher responds to my emails.	1	2	3	4	5
14.	I can ask other students what I do not understand during computer lessons.	1	2	3	4	5
15.	Other students respond positively to questions in relation to Internet lessons.	1	2	3	4	5
16.	I was encouraged by the positive attitude of my friends towards the Internet lessons.	1	2	3	4	5
17.	This mode of learning enables me to interact with other students and my teacher.	1	2	3	4	5
18.	I felt a sense of satisfaction and achievement about this learning environment.	1	2	3	4	5
19.	I enjoy learning in this environment.	1	2	3	4	5
20.	I could learn more in this environment.	1	2	3	4	5
21.	I can easily get students to work with me on the Internet.	1	2	3	4	5
22.	It is easy to work with other students and discuss the content of the lessons.	1	2	3	4	5

	STATEMENTS	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
23.	The web-based learning environment held my interest in this subject throughout this term.	1	2	3	4	5
24.	I felt a sense of boredom in this subject towards end of this term.	1	2	3	4	5
25.	I can work out exactly what each lesson on the Internet is about.	1	2	3	4	5
26.	The organisation of each lesson on the Internet is easy to follow.	1	2	3	4	5
27.	The structure of the lessons on the Internet keeps me focused on what is to be learned	1	2	3	4	5
28.	Internet lessons helped me better understand the work that was taught in class.	1	2	3	4	5
29.	Lessons on the Internet are well sequenced.	1	2	3	4	5
30.	The subject content is appropriate for delivery on the Internet.	1	2	3	4	5
31.	The presentation of the subject content is clear.	1	2	3	4	5
32.	The multiple choice test at the end of each lesson on the Internet improves my learning in this subject.	1	2	3	4	5

Please respond to these questions as best as you can. All answers should be in relation to the website *Getsmart* and web-based learning.

1. Do you think that *Getsmart* improved your results in Physics? Give reasons.

2. Do you believe that it is a good idea to supplement in class learning with teacher developed websites such as *Getsmart*? Give reasons.

3. What are some of the advantages of online learning when compared to in-class learning?

4. What are some of the disadvantages of online learning when compared to in-class learning?

5. What are some of the features of the websites which you thought were beneficial to you as a learner? Give reasons.

____

____

____

____

6. During computer lessons, did the website promote discussion on the lesson which you were doing between your colleagues and you? Give reasons.

____

____

____

____

____

7. What are your thoughts on the lesson tests?

____

____

____

____

____

8. Was the website accessible to your at all times? Give reasons.

____

____

____

____

____

9. What are some of the other features which should be incorporated in the website to improve learning outcomes?

____

____

____

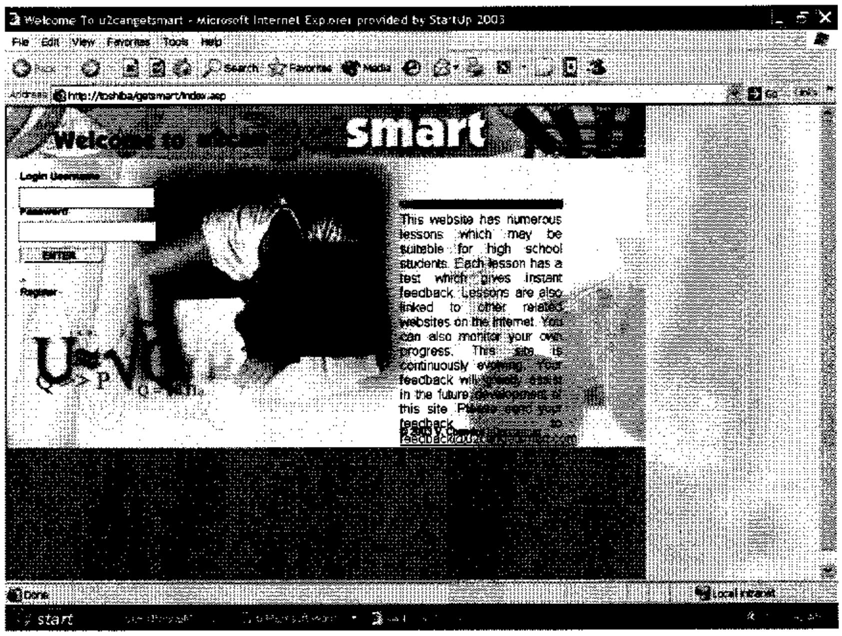
____

____

10. Do you have access to a reliable internet connection at all times? Yes/No

APPENDIX C

The Splash Page for Getsmart


Welcome To u2cangetsmart - Microsoft Internet Explorer provided by StartUp 2003
File Edit View Favorites Tools Help
Search Favorites Media
http://toshiba/getsmart/index.asp
smart
Login Username
Password
ENTER
Register
This website has numerous lessons which may be suitable for high school students. Each lesson has a test which gives instant feedback. Lessons are also linked to other related websites on the internet. You can also monitor your own progress. This site is continuously evolving.
this site.
feedback to
Done
Local intranet
start

APPENDIX D

The Content's Page of *Getsmart*

(Parts of the webpage were slightly modified to make it fit the page format in this thesis)

getsmart

CONTENT'S PAGE : CHOOSE YOUR TOPIC

YOU MAY CHOOSE YOUR TOPIC FROM THE LIST BELOW OR BY USING THE NAVIGATION BAR ABOVE. SOME OF THE LINKS WILL TAKE YOU OUTSIDE THIS WEBSITE TO http://users.bigpond.net.au/getsmart/start.htm . (Presently, some of the pages are under review and some links may not work properly.)

CHECK MY RESULTS NEW

CHECK MY LOGIN HISTORY NEW

SUBJECTS AND TOPICS

JUNIOR SCIENCE

ROAD SCIENCE What is speed? NEW, What does a graph tell us? NEW, What is acceleration? NEW ,Reaction time and reaction distance NEW, Inertia NEW, Force, mass and acceleration NEW, Revision 1 NEW, Revision 2 NEW

SPACE TRAVEL How does a rocket work?, Space Exploration, Space Travel Revision

GENETICS Introduction to Genetics (Lesson 1), Inheritance (Lesson 2), Predicting Crosses (Lesson 3), Pedigrees (Lesson 4), Blended Genes (Lesson 5), Sex-Linked Genes (Lesson 6), The structure of DNA (Lesson 7)

METALS AND NON-METALS Metals and Non-Metals

PHYSICS

MOTION Scalars & Vectors; Speed & Velocity, Acceleration, Equations of Motion; Motion graphs(1); Motion graphs(2), Application of motion concepts; Free falling objects, Projectile motion, Circular motion, Non-uniform circular motion, Review Questions(1), Review Question(2)

ENERGY & MOMENTUM Momentum; Conservation of momentum; Momentum Problems (1); Momentum Problems (2); Kinetic Energy; Potential Energy; Kinetic and Potential Energy combined ;Work and Energy; Forces(1), Forces(2), Review Questions

ELECTRONICS Semi conductors, More on doping, Common electronic components: Capacitors, Diodes, Light Dependent Resistors in action NEW , Capacitors in action NEW, NPN & PNP Transistors NEW, Logic Gates NEW, Electronics Revision NEW

ATOMIC PHYSICS History of the atom, The hydrogen atom, Frank-Hertz Experiment, Radioactivity, Radioactivity data analysis NEW, Binding Energy, Atomic Physics Revision NEW

ELECTRICITY AND MAGNETISM Electric charges (Chapter Summary), , Review questions , Electricity formula review

WAVES Interference

OPTICS Plane mirrors, Reflection in a curved mirror, Ray diagrams (concave mirrors), Ray diagrams (convex mirrors), Mirror formula, Practice ray diagrams (mirrors), Mirrors chapter summary, Refraction, Convex Lens, Concave Lens, Practice ray diagrams (lens), Lens formula, Optics revision

---

SENIOR PHYSICS TUTORIALS

Year 12 Physics Tutorial

USEFUL LINKS

Australian Academy of Science, The Franklin Institute, Assorted educational topics, Physical Science Hotlist, Museums of the world, NASA, Student & Teacher Resources (EdIndex) BBC, Education Queensland

APPENDIX E

Sample Lesson in Year 10 Science (Inertia and Momentum)

(Parts of the webpage were slightly modified to make it fit the page format in this thesis)

getsmart

KEY TERMS

Inertia

Newton's 1st law

Momentum

Impulse

KEY FORMULAE

p=mv

RELATED TOPICS

What is speed?

What does a graph tell us?

What is acceleration?

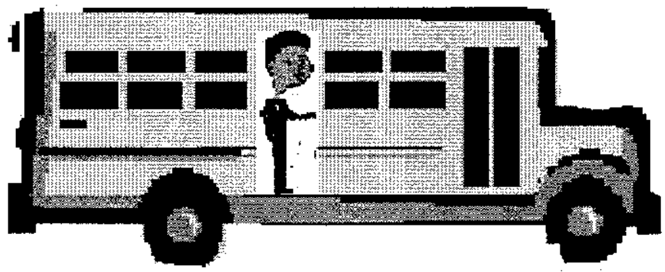
Reaction time and reaction distance

Inertia

Force, mass and acceleration

How does a rocket work?,

Inertia and Momentum



Justin is standing on this bus because there are no seats.

- What will happen to Justin as the bus accelerates (takes off)?
- What will happen to Justin as the bus decelerates (approaches a bus stop)?

Click here for an explanation

The observations made above are consistent with Newton's First Law or **Inertia**. As the bus slows down, Justin will continue to move forward because he is unrestrained (wearing no seat belts). A similar situation arises in a car when passengers or the driver do not wear seat belts. If the car stops suddenly, as a result of Inertia, passengers continue moving in the forward direction. Hence, they can suffer serious injury or even death if their bodies fly out of the windscreen or hit the dashboard. It is believed that seat belts reduce the risk of serious injury by up to 50%.

? Should all vehicles have seat belts? Give reasons.

What is inertia?

Inertia is described as a body's tendency to either stay at rest or remain in uniform motion unless acted upon by an external force. Inertia is dependent upon a body's mass. Thus, a truck has much greater inertia than a car.

Click on the any one of the following to see demonstrations on Inertia:

- The Car and The Wall
- The Motorcyclist
- The Truck and Ladder

USEFUL LINKS Physics Zone Virtual lab and simulations **EMAIL** Email a comment or query **RETURN TO** Home Page		

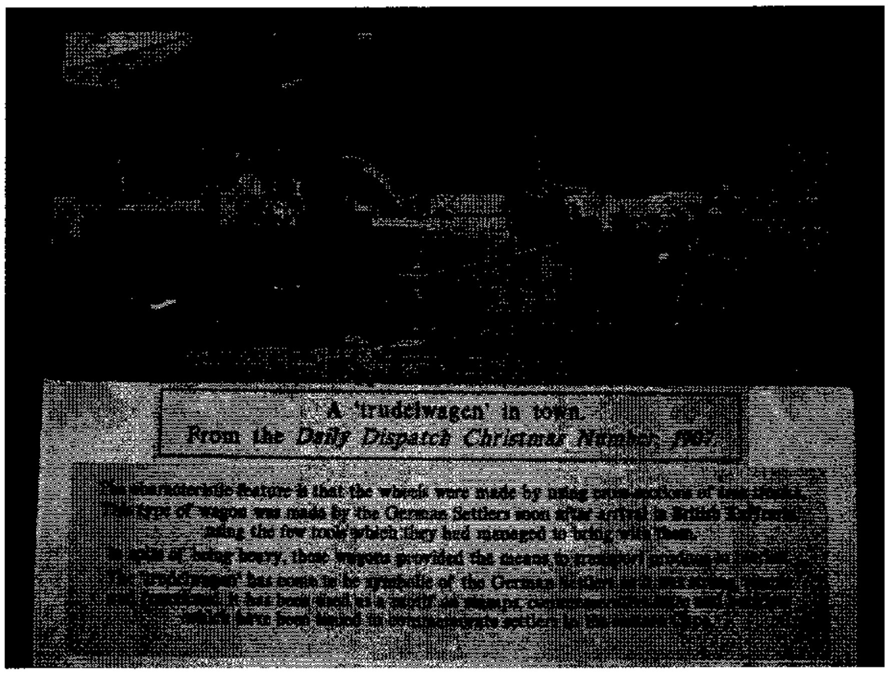
What is momentum?

Whilst Inertia depends on an object's mass, **momentum (p) is the product of an object's mass (m) and speed (v).**

$$p = m.v$$

Click here to see a demonstration on momentum.

Common units for momentum are kg ms^{-1} and g ms^{-1}. Thus, if the mass of an object is measured in kg and it's velocity is expressed in km hr^{-1}, then the unit of momentum becomes kg km hr^{-1}.



? Compare and contrast the Trudelwagon with today's automobiles.

What is impulse?

Impulse or the change in momentum of an object equals the product of force and time. It is determined as follows:

$F = ma$

$F = m(v - u)/t$

$Ft = mv - mu$

$Ft = \Delta p$ (final momentum - initial momentum)

Modern car manufacturers use this concept in the designing new cars by incorporating features like air bags and ABS brakes. Click here to read more about impulse and car crashes.

Impulse can also be determined by working out the area under a force time graph.

Click here (613 KB) or here (184 KB) to view a video clip of a plane taking off. (References will be made to this video clip in Test 1.)

? What happens to the inertia and momentum of the plane as it takes off? What happens to the inertia and momentum of the passengers as the plane takes off?

EXAMPLE 1

A car of mass 1250 kg is travelling at $15ms^{-1}$ (15m/s). Find its momentum.

WHAT'S GIVEN

m = 1250kg

v = 15 m/s

FORMULA

$p = mv$

WORKING

$p = mv$

= 1250 X 15

= **18 750 kg m/s**

EXAMPLE 2

A car of mass 1 600 kg is travelling at 30 ms^{-1} (30m/s). A truck of mass 10 000 kg is travelling at 4.8 m/s. Which vehicle has the greater momentum and which has more inertia?

WHAT'S GIVEN

Car: m = 1 600 kg, v = 30 m/s

Truck: m = 10 000, v = 4.8 m/s

FORMULA

p = mv

WORKING

For the car

p = mv

= 1 600 X 30

= **<u>48 000 kg m/s</u>**

For the truck

p = mv

= 10 000 X 4.8

= **<u>48 000 kg m/s</u>**

The truck and the car have the same momentum.

However, the truck has more inertia because it has greater mass.

Before proceeding to the next step, make sure you can explain the KEY TERMS in your own words. You should also ensure that you know how to apply the KEY FORMULAE. Seek help if you are in doubt.

This stuff is too easy - PLEASE take me to test 1

This stuff is too easy - PLEASE take me to test 2

APPENDIX F

Sample Test in Year 10 Science (Reaction Time and Distance Test)

(Parts of the webpage were slightly modified to make it fit the page format in this thesis)

REACTION TIME AND DISTANCE TEST

QUESTION a1

A car is travelling at 60 km/h. What is its speed in m/s?

a) 60 m/s

b) 30 m/s

c) 21.2 m/s

d) 16.7 m/s

e) 6.7 m/s

QUESTION a2

How far does the car in Question 1 travel in 1 second?

a) 60 km

b) 60 m

c) 16.7 km

d) 16.7 m

e) 1/60 m

QUESTION a3

Mickey is driving his car at 60 km/h. His reaction time is 0.8s. What is his reaction distance?

a) 13.4 m b) 13.1 m c) 13 m d) 13 km
e) 13 cm

QUESTION a4

Stopping distance =

a) braking distance

b) reaction distance

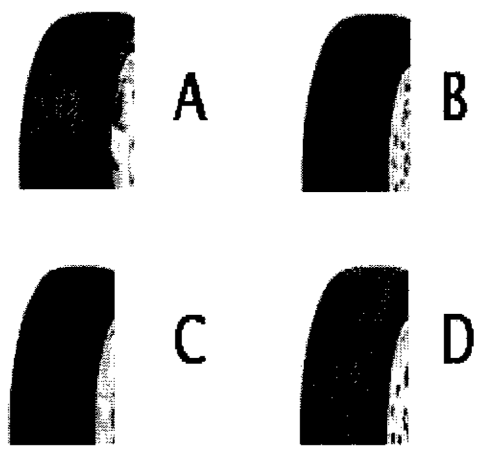
c) braking distance + reaction distance

d) braking distance - reaction distance

e) reaction distance - braking distance

QUESTION a5

Which one of the following tyres will have the shortest braking distance if the speed of the car and the driver's reaction time is the same?



a) A

b) B

c) C

d) D

e) More information is needed

QUESTION a6

The following link logs you onto the Goodyear Tyres website. Open this link (http://tires2.digiknow.com/goodyear/results_vehicle.jsp?year=2001&make=TOYOTA&model=Avalon&option=XLS) and from the information provided on this website, decide which one of the tyres would be best suited for wet road conditions?

a) ○ Eagle#1

b) ○ Eagle GA

c) ○ Eagle GT II

d) ○ Eagle HP

e) ○ Eagle RS-A

QUESTION a7

You own a taxi in Brisbane. Open the Goodyear Tyres website (http://tires2.digiknow.com/goodyear/results_vehicle.jsp?year=2001&make=TOYOTA&model=Avalon&option=XLS) and decide which one of the following tyres would be best for your taxi?

a) ○ Eagle#1

b) ○ Eagle GA

c) ○ Eagle GT II

d) ○ Eagle LS

e) ○ Eagle RS-A

QUESTION a8

The following data is collected from a series of tests in a university physics project. It shows the reaction, braking and total stopping distance at various speeds. What is the reaction distance at 40 km/h?

Speed (km/h)	Reaction distance(m)	Braking distance(m)	Total distance(m)
20	5	5	10
40	?	15	?
60	15	30	45
80	20	50	70
100	?	75	?
120	30	?	?

a) 5m b) 7.5m c) 10m d) 15m e) 20m

QUESTION a9

Use the data in the table in Question a8 and work out the total stopping distance at 100 km/h?

a) 25m b) 50m c) 75m d) 100m e) 125m

QUESTION b1

From the data provided in the table in Question a8, it can be concluded that the total stopping distance at 120 km/h is about:

a) 110m b) 120m c) 130m d) 140m e) 150m

Submit Answers

APPENDIX G

Sample Revision Lesson in Year 10 Science (Motion)

(Parts of the webpage were slightly modified to make it fit the page format in this thesis)

KEY TERMS

Acceleration

Average speed

Braking distance

Constant

Crumple Zone

Deceleration

Directly proportional

Final speed

Force

Friction

Inertia

Initial speed

Inversely proportional

Mass

Momentum

Motion Graphs

Newton's 1st Law

Newton's 2nd

Revision Questions 1

1. Define speed. What is the formula for working out speed? Help

2. Give examples of the units of speed. Help

3. A truck is travelling at 60 km/h. What is its speed in m/s? Help

4. Express 12 m/s in km/h. Help

5. Complete the following:

distance =____________X _______________

time = ____________ ÷ ______________ Help

6. Define the term average speed

7. A truck travels 760km in 6.5 hours. Find its average speed. Help

8. Tim set a new school record in 1999 when he ran 400m at a speed of 9.2 m/s. How long did this sprint take? Help

9. Your car's average speed to Sydney on your last trip was 80 km/h. What was the speed of your car in m/s? Help

10. Draw a graph from the information given in the table below:

Time (s)	0	2	4	6	8	10	12	14	16	
Distance (m)	0	2	3	3	10	15	15	11	0	

From your graph answer the following questions:

a) During which time intervals is the object stationary?

b) What was the speed of the object between t=0 to t =4?

c) When was the object travelling fastest?

Law

Reaction distance

Reaction time

Speed

Static & Sliding friction

Stopping distance

KEY FORMULAE:

v = d/t or s/t

a = v - u /t

p = mV or

M = mv

F = ma

RELATED TOPICS:

What is speed?

What does a graph tell us?

What is acceleration?

Reaction time and reaction distance

Inertia

Force, mass and acceleration

How does a rocket work?

d) For how many seconds in total was the object at rest?

e) What happens to the object after 12 seconds? Help

11. Draw a speed-time graph from the following information:

Time (s)	0	2	4	6	8	10
Speed (m/s)	10	4	4	8	9	10

From your graph answer the following questions:

a) What is happening to the object in the first 2 seconds?

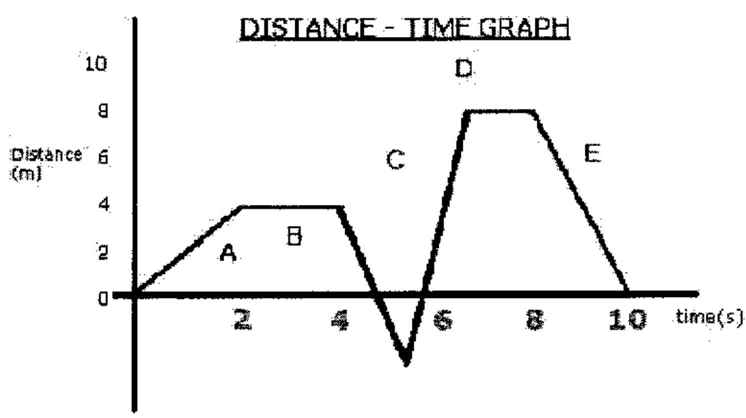
b) In which time interval is the object travelling at constant speed?

c) What happens to the speed of the object after 4 seconds?

d) Describe the entire motion of the object (use the terms accelerate, decelerate and constant speed in your discussion).

Help

12. Describe the motion of the object represented by the graph below:



13. Recall all key formulae and explain meanings of all key terms in the column on the left hand side.

APPENDIX H

Sample Student Worksheet in Year 10 Science (Inertia and Momentum)

(Parts of the webpage were slightly modified to make it fit the page format in this thesis)

Internet Lesson Worksheet Number 5

Inertia and Momentum

Log onto the Inertia and Momentum lesson on *Getsmart* and complete this worksheet. You have to answer the questions and fill in the blanks.

Justin is standing on this bus because there are no seats.

1. What will happen to Justin as the bus accelerates (takes off)?

____

____

____

2. What will happen to Justin as the bus decelerates (approaches a bus stop)?

____

____

____

The observations made above are consistent with Newton's First Law or__________. As the bus slows down, Justin will continue to move forward because he is unrestrained (wearing no seat belts). A similar situation arises in a car when passengers or the driver do not wear seat belts. If the car stops suddenly, as a result of __________, passengers continue moving in the __________ direction. Hence, they can suffer serious injury or even death if their bodies fly out of the windscreen or hit the dashboard. It is believed that ________ __________ reduce the risk of serious injury by up to 50%.

? Should all vehicles have seat belts? Give reasons.

____

____

____

What is inertia?

Inertia is described as a body's tendency to either stay at _________or remain in ___________ ____________ unless acted upon by an external force. Inertia is dependent upon a body's mass. Thus, a truck has much _________ inertia than a car.

What is momentum?

Whilst Inertia depends on an object's _________, **momentum (p) is the product of an object's __________ and speed (v).**

$$p = m.v$$

Common units for momentum are ______ and _______. Thus, if the mass of an object is measured in kg and it's velocity is expressed in km hr^{-1}, then the unit of momentum becomes _____________.

? Compare and contrast the Trudelwagon with today's automobiles.

____

____

____

What is impulse?

Impulse or the change in momentum of an object equals the product of force and time. It is determined as follows:

F = ma

F =

Ft =

Ft = Δp (final momentum - initial momentum)

Modern car manufacturers use this concept in the designing new cars by incorporating features like _______ _______ and _______ brakes.

? What happens to the inertia and momentum of the plane as it takes off? What happens to the inertia and momentum of the passengers as the plane takes off?

____

____

____

EXAMPLE 1

A car of mass 1250 kg is travelling at $15ms^{-1}$ (15m/s). Find its momentum.

WHAT'S GIVEN

m = 1250kg

v = 15 m/s

FORMULA

p = mv

WORKING

p = mv

=

=

EXAMPLE 2

A car of mass 1 600 kg is travelling at 30 ms^{-1} (30m/s). A truck of mass 10 000 kg is travelling at 4.8 m/s. Which vehicle has the greater momentum and which has more inertia?

WHAT'S GIVEN

Car: m = , v =

Truck: m = , v =

FORMULA

p = mv

WORKING

For the car

p = mv

=

= **48 000 kg m/s**

For the truck

p = mv

= 10 000 X 4.8

=

The truck and the car have the ________ momentum.

However, the truck has more __________ because it has __________ mass.

APPENDIX I

Sample Lesson in Year 12 Physics (The Hydrogen Spectrum)

(Parts of the webpage were slightly modified to make it fit the page format in this thesis)

KEY TERMS

nucleus

shells/orbits

protons

electrons

atomic number

ground state

excited state

photons

electron volts (eV)

emission spectrum

nanometres

frequency

energy

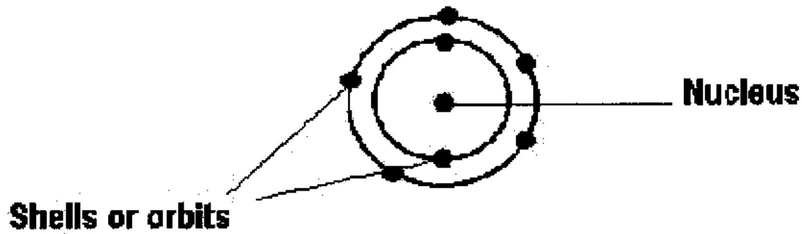
Planck's constant

Rydberg's formula

THE HYDROGEN SPECTRUM

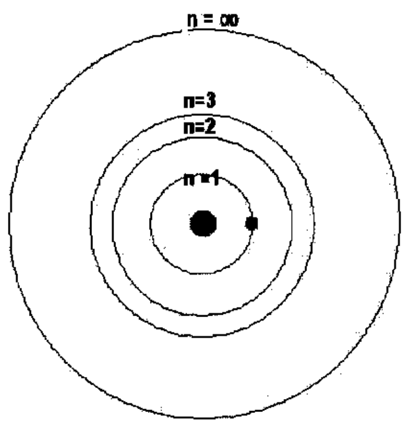
What are atoms made of?

Our modern knowledge of an atom suggests that it is made up of a nucleus and shells or orbits. The nucleus contains protons (positively charged particles) and neutrons (uncharged particles). Electrons (negatively charged particles) are found in shells or orbits.



What is a hydrogen atom made of?

A hydrogen atom has an atomic number of 1 which means that it has one proton and 1 electron. This single electron is found in the first shell when the hydrogen atom is in its lowest energy state **known as** ground state. **However, if the electron is given the** right amount of energy **by another particle, then it can move to a higher energy level. When the electron moves to a higher energy level, then hydrogen atom is said to be in an** excited state.



A hydrogen atom in ground state is shown in the diagram above. The electron (shown in purple) can gain energy and move to a higher level such as n =2, 3 , 4....∞. When the electron is excited to the ∞ (infinity) level, the atom is said to be ionised.

KEY FORMULAE

$1 / \lambda = R_H (1/n^2 - 1/m^2)$

(Rydberg formula)

$c = f \lambda$

$E = h f$

$E = h c / \lambda$

RELATED TOPICS

History of the atom

The hydrogen atom

Frank-Hertz Experiment

Radioactivity

Binding Energy

USEFUL LINKS

Physics Zone

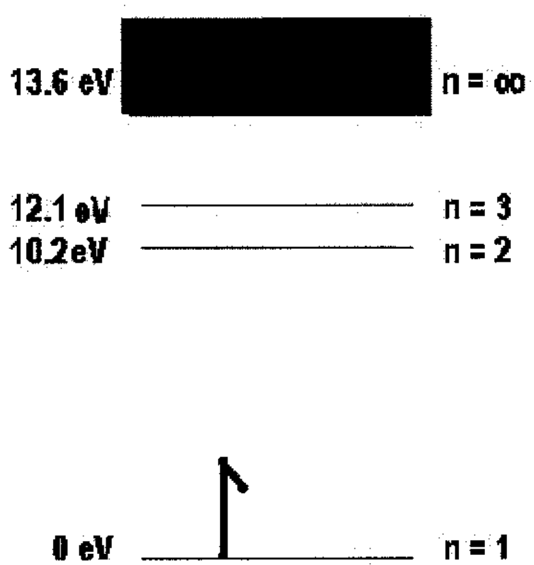
Glenbrook High

Virtual lab and simulations

EMAIL

Email a comment or query

How much energy is needed to move electrons between levels in a hydrogen atom?



The diagram above shows the energy levels in a hydrogen atom. The electron (shown with half an arrowhead) in level 1 can gain energy and move to level provided it is "given" 10.2 eV of energy. (1 eV = 1.6×10^{-19}J of energy). If this electron is given 12.1 eV it will move from n = 1 to n = 3. However, if the electron is given 10.1 eV it will not move to a higher level.

What happens to the electron after it has moved to a higher level?

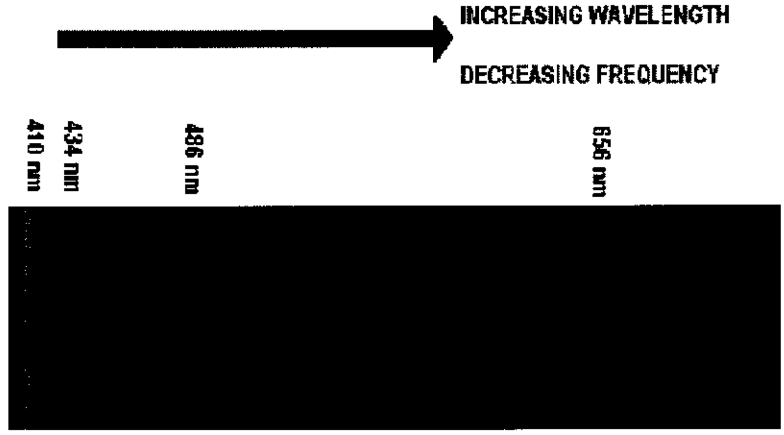
Assume that an electron has been excited to n = 3 from n = 1. This excited electron will then drop back to n = 1. It can go directly from n = 3 to n = 1 or it go from n = 3 to n =2 and then to n =1. As it drops back, it gives off photons of energy. This equals the energy it had absorbed initially to jump to a higher energy level.

Discrete lines in the emission spectrum of hydrogen correspond to the photons of energy given off when electrons fall from one higher energy level to a lower one. Part of the visible region of the emission spectrum of hydrogen is shown below. The line at 656 nm for instance is due to an electron dropping from the third energy level to the second one.

RETURN TO

Home Page

Choose Your Topic Page



HYDROGEN LINE SPECTRUM

What is the Rydberg formula used for?

Rydberg formula : $1 / \lambda = R_H (1/n^2 - 1/m^2)$

where $R_H = 1.097 \times 10^7 \, m^{-1}$ (the Rydberg constant for hydrogen)

n = lower level, m = higher level

The Rydberg formula is used to determine the wavelength of the discrete lines found in the emission spectrum of an atom. The Rydberg constant is different for different atoms. The frequency associated with a certain can also be calculated by using the formula :

$c = f \lambda$

where c = speed of light

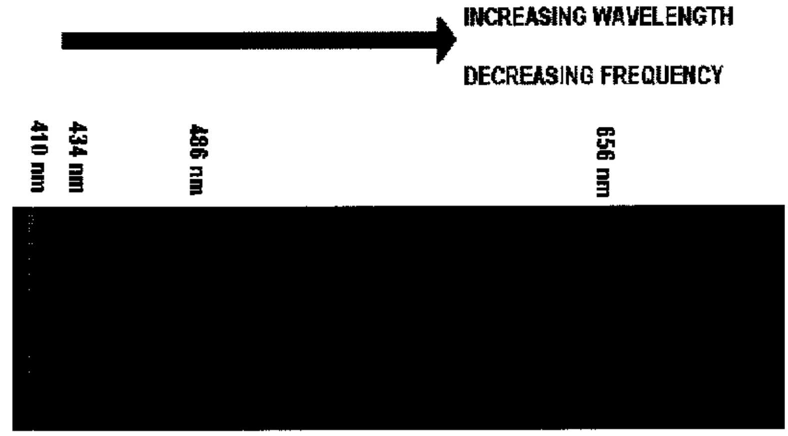
f = frequency of light

The amount of energy associated with each frequency or wavelength in the emission spectrum of an atom is determined by the formula:

$E = h f = h c / \lambda$

where E = energy, h = Planck's constant, f = frequency

EXAMPLE



The emission spectrum of hydrogen is shown above.

a) Prove that the discrete line shown at 656 nm is due an electron dropping from the third to the second level.

b) How much energy is given off by this photon in eV?

What's given: λ **= 656 nm, n = 2, m = 3**

Formulae needed : **1 /** λ **=** $R_H(1/n^2 - 1/m^2)$

$c = f\lambda$

$E = hf$

1 ev = 1.6×10^{-19} **J**

a) $1/\lambda = R_H(1/n^2 - 1/m^2)$

$= 1.097 \times 10^7\ m^{-1}\ (1/2^2 - 1/3^2)$

$= 1.097 \times 10^7\ m^{-1}\ (1/4 - 1/9)$

$= 1.097 \times 10^7\ m^{-1}\ (5/36)$

$\lambda = 6.56 \times 10^{-7}$ m = 656 nm

		b) $E = hf = hc/\lambda$ $= 6.6 \times 10^{-34} \times 3 \times 10^{8} / 6.56 \times 10^{-7}$ $= 3.02 \times 10^{-19}$ J **1 ev =** 1.6×10^{-19} **J** $E = 3.02 \times 10^{-19} / 1.6 \times 10^{-19}$ = 1.89 eV <u>**This stuff is too easy - PLEASE take me to the test page**</u>

APPENDIX J

Sample Test Page in Year 12 Physics (The Hydrogen Spectrum Test)

(Parts of the webpage were slightly modified to make it fit the page format in this thesis.)

HYDROGEN ATOM TEST

Click on the button representing the best answer. Each question is worth 1 mark. If you do not get full marks, repeat the test until you do.

QUESTION 1

What is the atomic number of the atom shown in the diagram below?

a) 2
b) 5
c) 7
d) 8
e) Cannot be determined

QUESTION 2

Hydrogen has 1 electron. In which one of the following situations would the hydrogen atom be said to be in an excited state?

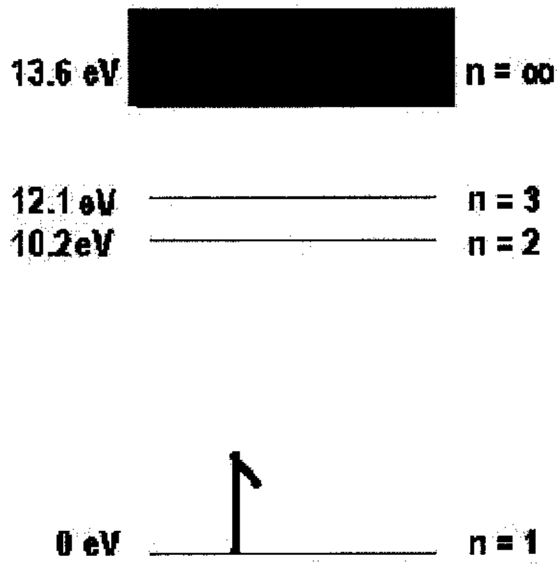
a) When the electron is in level 1
b) When the electron is in level 2
c) When the electron is in level 3
d) When the electron is at 8
e) At all levels except 1

QUESTION 3

Moving an electron from ground state to which level requires the most energy:

a) 8
b) 1
c) 2
d) 3
e) 10

QUESTION 4



The diagram above shows the energy levels in a hydrogen atom. How much energy is needed to excite an electron from level 1 to 3?

a) ○ None

b) ○ 10.2 eV

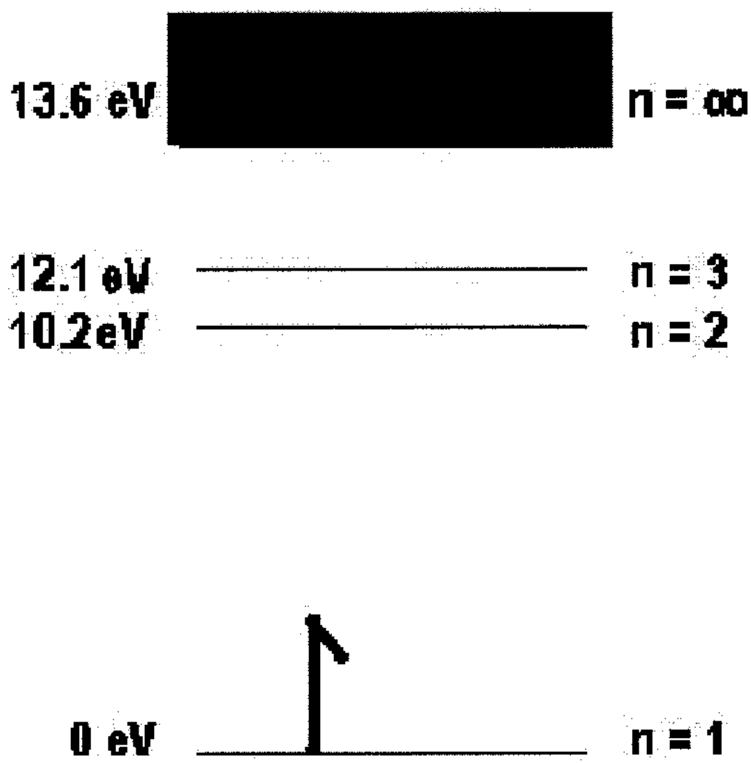
c) ○ 12.1 eV

d) ○ 22.3 eV

e) ○ More information is needed

QUESTION 5

The diagram below shows the energy levels in a hydrogen atom. How much energy is needed to ionise a hydrogen atom?



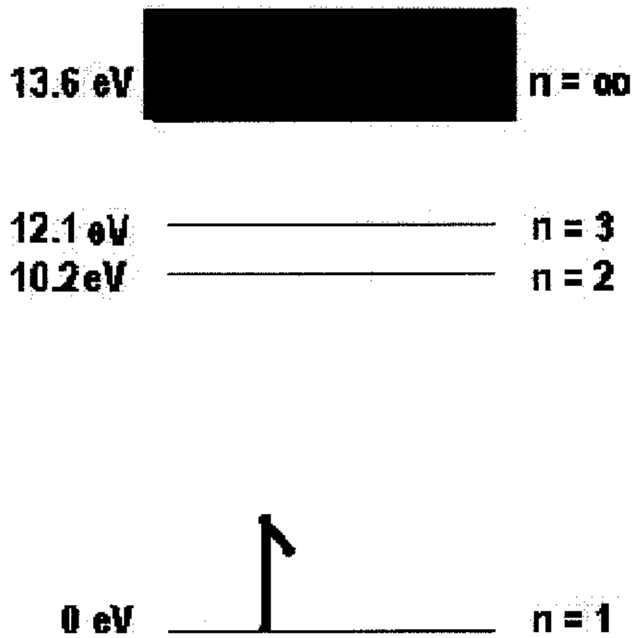
a) 13.6 eV
b) 12.1 eV
c) 10.2 eV
d) 13.6 + 12.1 + 10.2 eV
e) None of the above

QUESTION 6

In a hydrogen atom, an electron drops from level 6 to level 2. The inverse of the wavelength observed in the emission spectra will equal:

a) 1.097 X 10^7 (1/2^2 - 1/3^2) m^-1
b) 1.097 X 10^7 (1/6^2 - 1/2^2) m^-1
c) 1.097 X 10^7 (1/2^2 + 1/6^2) m^-1
d) 1.097 X 10^7 (1/2^2 - 1/6^2) m^-1
e) 1.097 X 10^7 (1/2^2 - 1/2^6) m^-1

QUESTION 7



The frequency of the energy associated with the electron as it drops from the second level is given by:

a) 10.2 X 1.6 X 10^-19 / 6.6 X 10^-34

b) 10.2 / 6.6 X 10^-34

c) 10.2 X 6.6 X 10^-34 / 1.6 X 10^-19

d) 10.2 X 1.6 X 10^-19 + 6.6 X 10^-34

e) 10.2 /1.6 X 10^-19 X 6.6 X 10^-34

QUESTION 8

A photon in the emission spectrum of sodium produces a discrete line at 589.0 nm. How much excitation energy was needed to produce this line?

a) 3.371 X 10^-19 J

b) 3.371 X 10^19 J

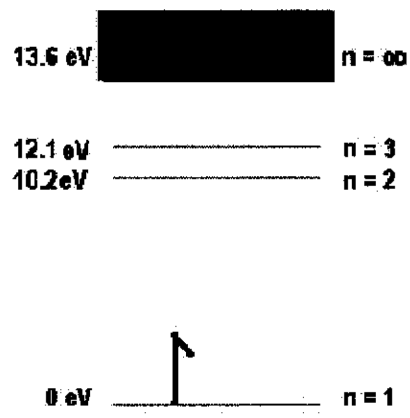
c) 5.371 X 10^-19 J

d) 8.371 X 10^-19 J

e) 8.731 X 10^-19 J

QUESTION 9

A particle with 9.6 eV of energy collides with the electron shown in the diagram above. As a result of this collision:



a) The electron will move to level 1

b) The electron will move to level 2

c) The electron will move to level 3

d) The particle will loose all its energy

e) The electron will be unaffected

QUESTION 10

Which one of the following statements is correct?

a) A photon which drops from level 7 to level 1 has a lower energy than a photon which drops from level 6 to level 1.

b) A photon which drops from level 7 to level 1 has a lower frequency than a photon which drops from level 6 to level 1.

c) A photon which drops from level 7 to level 1 a larger wavelength than a photon which drops from level 6 to level 1.

d) A photon which drops from level 7 to level 1 has the same energy, frequency and wavelength as a photon which drops from level 6 to level 1.

e) A photon which drops from level 7 to level 1 has more energy than a photon which drops from level 6 to level 1.

Submit Answers

APPENDIX K

Sample Activity in Year 12 Physics (Radioactivity Lesson and Activity)

(Parts of the webpage were slightly modified to make it fit the page format in this thesis)

Radioactivity Data Analysis

Click here to download the lesson worksheet.

Background Information : Mathematical Interpretation of a decay curve

In the equation below:

$$N(t) = N_o\,(½)^n = N_o\,2^{-n}$$

Since, the decay curve follows an exponential path, the decay equation above can also be expressed as follows with different variables:

$$N(t) = N_o\,e^{-\lambda t}$$

Where N(t) is defined as the mass (or activity) of particles at time, t.

And N_o is the mass (or activity) of the original sample.

And λ == decay constant, t=time

In this activity you will see a simulation of the decay of a radioactive isotope. The activity of the isotope (in counts per second) is measured every three seconds. Your task is to download the activity worksheet, record the data, draw a graph and answer questions which follow.

Questions

Use your graph to answer the questions where possible.

1. Click here to view the simulation.

2. What is the half-life of the isotope?

3. What is the decay constant of the substance?

4. Use your result in Q.2 to verify the following result - half life = 0.6931/decay constant.

5. On your graph, sketch the decay curve of a substance with a half life of 30s. Compare and contrast the two sketches.

Radioactivity Data Analysis

In this activity you will see a simulation of the decay of a radioactive isotope. The activity of the isotope (in counts per second) is measured every three seconds**. Your task is to download this worksheet, record the data, draw a graph and answer questions which follow.**

Questions

1. Complete the following table:

Time(s)	Activity (counts)	Time(s)	Activity (counts)	Time(s)	Activity (counts)
0		**24**		**48**	
3		**27**		**51**	
6		**30**		**54**	
9		**33**		**57**	
12		**36**		**60**	
15		**39**		**63**	
18		**42**		**66**	
21		**45**		**69**	

2. Use the data above to complete a graph in the space below:

Use your graph to answer the questions where possible.

3. What is the half-life of the isotope?

4. What is the decay constant of the substance?

5. Use your result in Q.2 to verify the following result - half life = 0.6931/decay constant

6. On your graph, sketch the decay curve of a substance with a half life of 30s. Compare and contrast the two sketches.

APPENDIX L

Sample Revision Lesson in Year 12 Physics (Electronics)

(Parts of the webpage were slightly modified to make it fit the page format in this thesis)

Electronics Revision Test 1 - Short Answers

FILL IN THE BLANKS. DO NOT LEAVE ANY SPACES IN YOUR ANSWER(S) UNLESS YOU HAVE BEEN ASKED TO DO SO.

QUESTION 1

When current flows through the diode, it is said to be forward ______. When the diode is ______ biased, no current flows through it.

QUESTION 2

A ______ is used in circuits to stop the flow of current in unwanted directions.

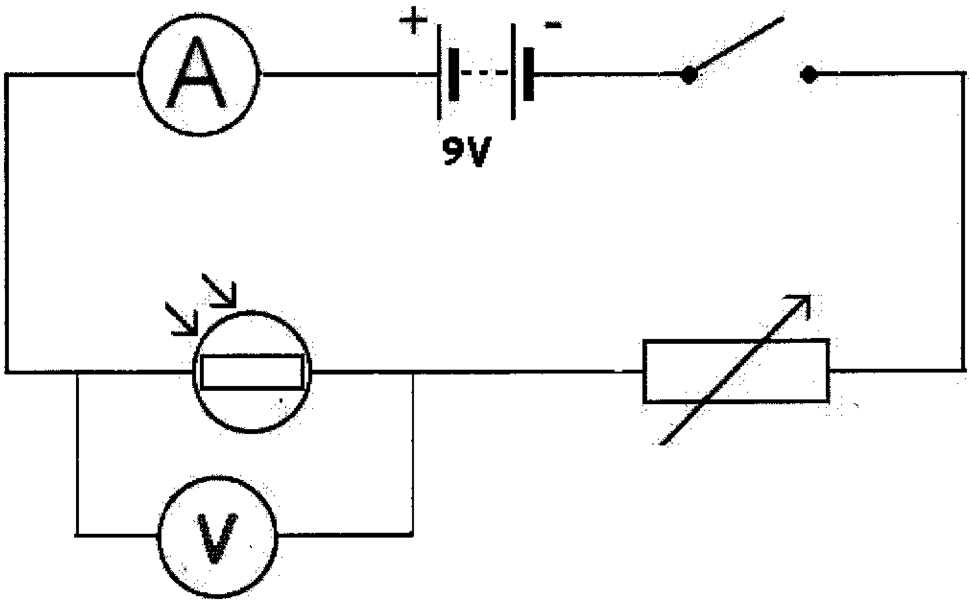
QUESTION 3

The resistance of a ______ is high when no light falls on it. It is ______ when light falls on it. This feature enables it to be used in burglar alarms.

QUESTION 4

A ______ is used in circuits which operates under varying temperature conditions.

QUESTION 5



In the diagram below, when the switch is closed, the voltmeter reads 3V and the ammeter reads 0.5A. The voltage across variable resistor would be ________ volts and its resistance would be ________ ohms. The resistance of the variable resistor would be ________ ohms. When no light falls on the LDR, its resistance and voltage ________ .

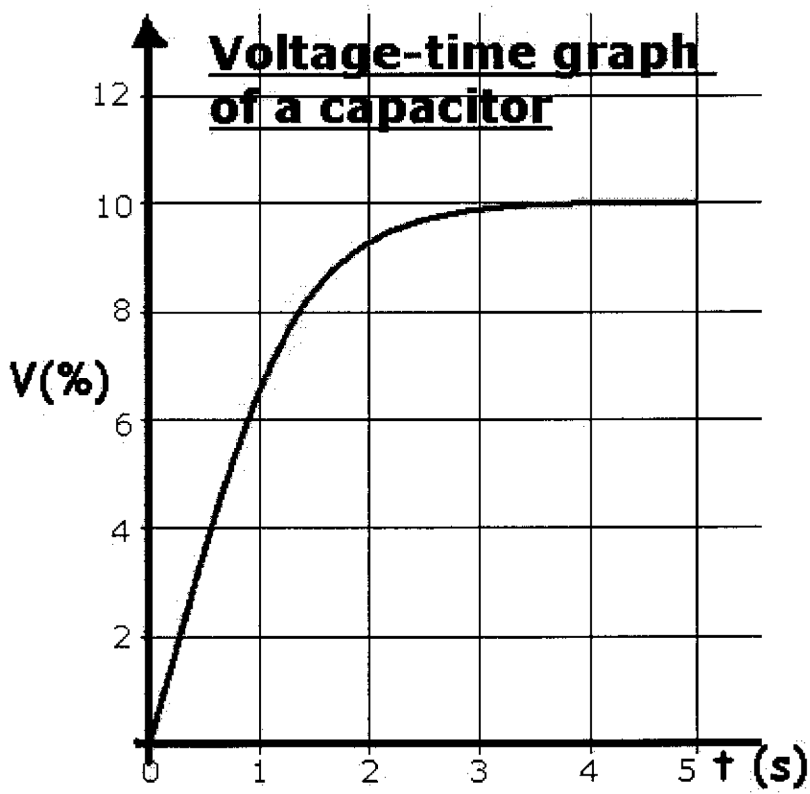
QUESTION 6

A semi-conductor (e.g. Silicon) has properties conduction properties which lie between a ________ and a non-metal. ________ improves conduction properties of a semi-conductor. When minute quantities of phosphorous are added to silicon, a ________ type silicon or semi-conductor is produced. When boron is added to a silicon in minute quantities, a ________ type semi-conductor is produced. Such additions create ________ in the silicon structure.

QUESTION 7

A capacitor stores charges. The charging of a capacitor produces an ________ curve. The time constant is defined as the time it takes a capacitor to reach ________ % of its supply voltage. It takes 5 time constants before a capacitor is fully charged. The time constant is a product of resistance and ________ . A capacitor (100 µF) is hooked to 10kΩ resistor. The time constant is ________ s and it takes ________ s for it to be fully charged.

QUESTION 8



The graph below shows the percentage changes in the voltage of a capacitor as it charges. The time constant of the capacitor is [ ] s. It takes [ ] times the time constant for the capacitor to fully charge itself. Hence. in this instance the capacitor is fully charged after [ ] s.

QUESTION 9

AC voltages can be converted to DC by a process called [ ]. A [ ] connected to an AC source produces a [ ] rectification. A [ ] can also be used which smoothes out the wave. Full-wave rectifiers consist of [ ] diodes arranged in a "bridge formation".

Submit Answers

APPENDIX M

Sample Practice Lesson in Year 11 Physics (Ray Diagrams)

(Parts of the webpage were slightly modified to make it fit the page format in this thesis)

KEY TERMS

convex mirror

concave mirror

plane mirror

principal axis

principal focus

pole

real image

virtual image

magnified

diminished

inverted

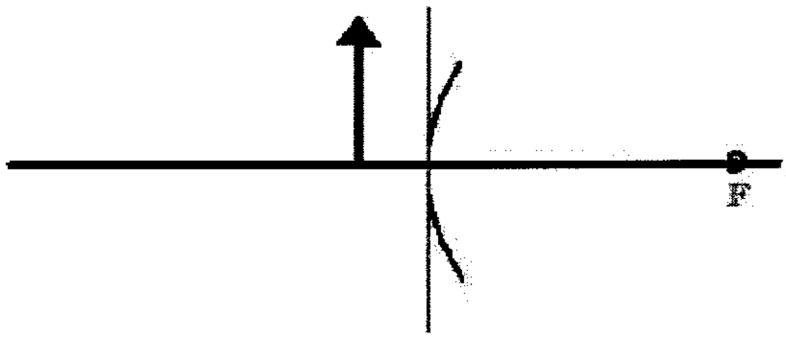
upright

laterally reversed

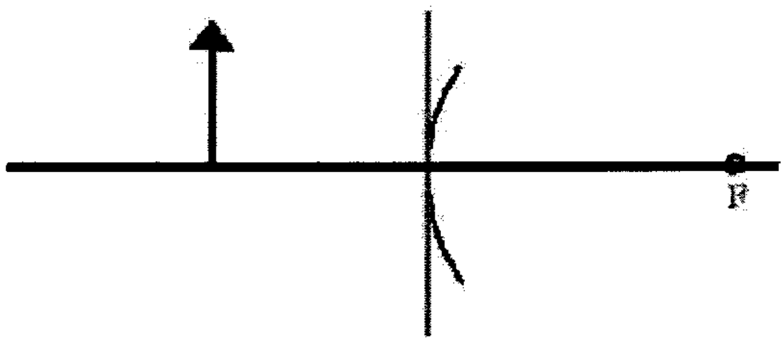
KEY FORMULAE

Practice drawing ray diagrams

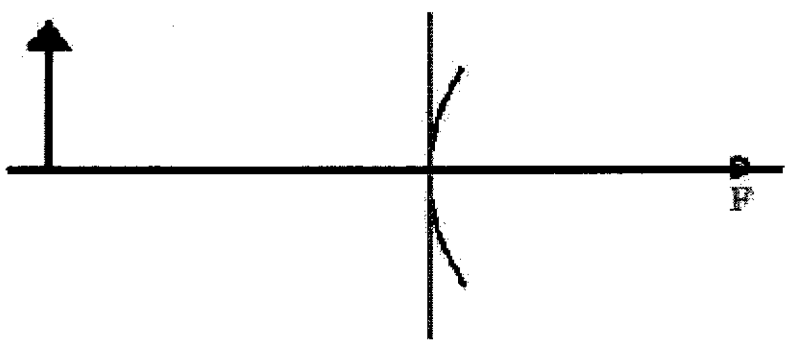
Practice 1



Practice 2



Practice 3



RELATED TOPICS	Practice 4

RELATED TOPICS

Plane mirrors

Reflection in a curved mirror

Ray diagrams (concave mirrors)

Ray diagrams (convex mirrors)

Mirror formula

Refraction

USEFUL LINKS

Physics Zone

Virtual lab and simulations

EMAIL

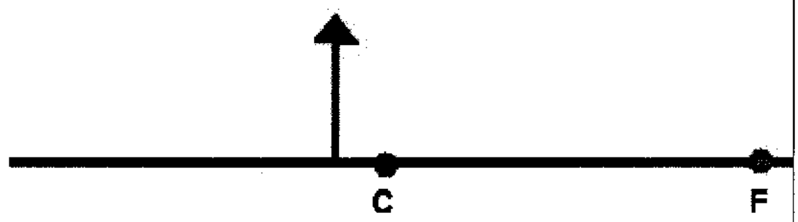
Email a comment or query

RETURN TO

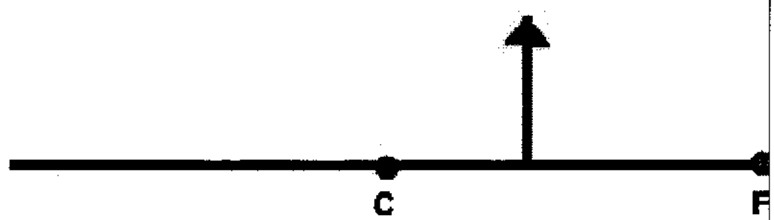
Home Page

Choose Your Topic Page

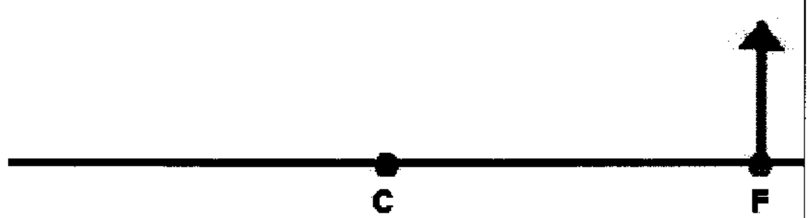
Practice 4

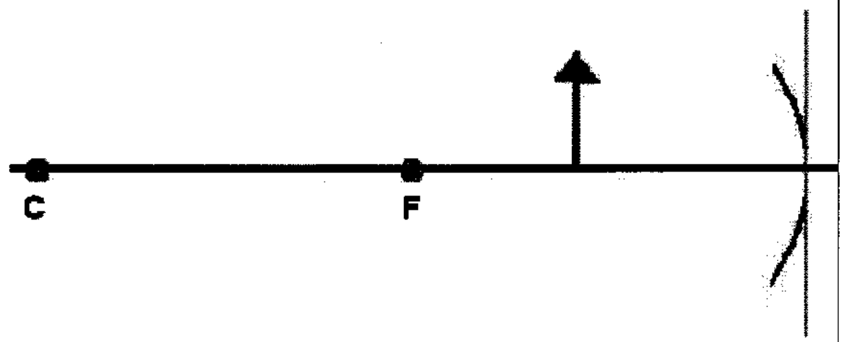
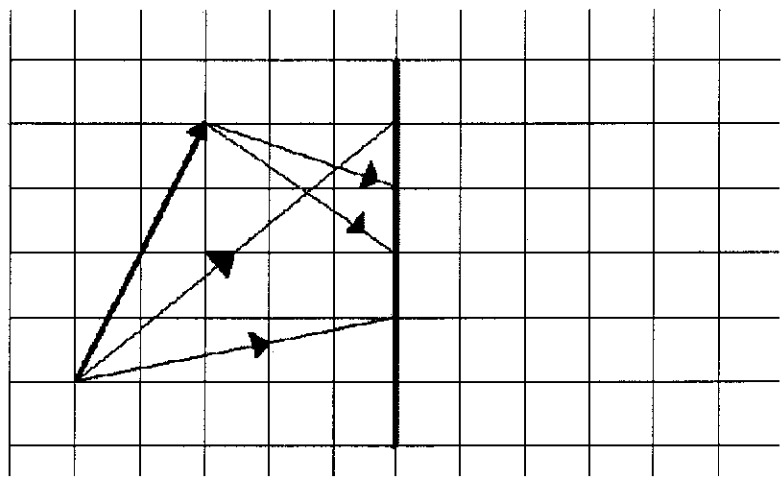


Practice 5



Practice 6



	Practice 7  **Practice 8** 

APPENDIX N

Sample Student Designed Webpage in Year 12 Physics (Electric Charges)

(Parts of the webpage were slightly modified to make it fit the page format in this thesis)

getsmart

Electric Charges (Answers to key questions)

A response to Question 1

Static electricity is related to stationary charges (as opposed to moving ones in current electricity). "Static" is often observed when insulators are rubbed together and electrons are transferred from one insulator to the other.

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A response to Question 2 by B.Q

All substances are made of atoms. Atoms contain positively charged particles called protons, and negatively charged particles called electrons. Uncharged particles are called neutrons. When two objects are rubbed together, they can lose or gain electrons from each other. If an object loses electrons, that object becomes positively charged. If an object gains electrons, it becomes negatively charged.

The unit for measuring a quantity of electric charge is the coulomb (C). One coulomb is the charge on approximately 6.24×10^{18} electrons.

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A response to Question 3 by J.T. and J.Y.

An instrument that can detect the presence of an electric charge is the electroscope. The typical electroscope consists of metal plate on top of a stem. A very thin metal leaf is attached to the stem. The leaf is hinged to the stem so that it can move. The case protects the internal system from outside influences.

When a positively charged rod is brought near the top plate, the leaf moves up, signifying the presence of an electric charge. This also occurs when a negatively charged rod is brought near the top plate. An electroscope can also be charged by rubbing a charged rod firmly across the edge of the top plate. In this way, the charge of the rod is shared with the electroscope.

In general, if an object is held near a charged electroscope and causes the leaf to rise further, it has the same kind of charge as the electroscope. If it causes the leaf to fall, it has a different kind of charge or is uncharged. Therefore an electroscope is only able to detect the polarity of an electric charge.

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A response to Question 4

An electroscope can be used to detect the presence of a charge, detect the type of charge, measure the amount of charge.

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A response to Question 5 by A.L. and D. P.

Answer currently under review

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A response to Question 6 by A.S.

Two electric charges that are brought together will be either attracted or repelled by a force between them. Whether this force is attraction or repulsion will depend on the nature (sign) of the two charges.

Charles Coulomb found that electric force is proportional to the product of the charges. He also found that the electric force is inversely proportional to the square of the distance between the two charges. Put these together, and you have the equation –

$$F = \frac{k\, q_1\, q_2}{d^2}$$

where F = force on either charge (in Newtons)

q_1 and q_2 = the two charges (in Coulombs)

d = the distance between the charges (in metres)

k = a constant of proportionality equal to 9×10^9 N m^2 C^{-2}

If q_1 and q_2 have the same charge- the force will be repulsive.

If q_1 and q_2 have opposite charges - the force will be attractive.

Example

Two charges 10cm apart in a vacuum have charges of +6μC and -8μC respectively. What is the electric Force between them?

What's given?

$q_1 = 6\mu C = 6 \times 10^{-6}$ C $d = 10cm = 0.1m$

$q_2 = 8\mu C = 8 \times 10^{-6}$ C $k = 9 \times 10^9 \ N \ m^2 \ C^{-2}$

(+ve and –ve signs are not used in calculations)

Formula

$$F = k \, q_1 q_2 / d^2$$

Working

$$F = \frac{9 \times 10^9 \times 6 \times 10^{-6} \times 8 \times 10^{-6}}{0.1^2}$$

$$F = 43.2 \ N$$

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A response to Question 7 by K.W. and T.P.

What's given?

$q_1 = 30\mu c = 3x10^{-5}$ c

$q_2 = 40\mu c = 4x10^{-5}$ c

d = ?

F = 750N

$k = 9x10^9$

Formula

$F=kq_1q_2 / d^2$

Working

$750 = 9x10^9 \text{ X } 3x10^{-5} \text{ X } 4x10^{-5}/d^2$

$d^2 = 9x10^9 \text{ X } 3x10^{-5} \text{ X } 4x10^{-5}/750$

$d^2 = 10.8/750$

$d^2 = 0.0144$

$d = 0.12m$

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A response to Question 8

An electric field is any region where an electric charge experiences a force. An electric field is represented by field lines which give the direction of the force exerted on a positive charge. The closer these lines, the stronger is the field.

The electric field strength (E) is the force (F) acting on a unit positive charge(q).

$E = F/q$

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A response to Question 9 by S.G.

A charge in an electric field experiences a force according to coulomb's law. When a small positive charge is held in contact with the positive plate and then released, it will move towards the lower plate. As it does its potential energy will become kinetic energy.

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A response to Question 10

$F = kq_1q_2/d^2$, $F = Eq$, $E = kq/d^2$, $W = Vq$, $V = Ed$

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APPENDIX O

Sample User Record (Login and Online Test Results)

(Parts of the webpage were slightly modified to make it fit the page format in this thesis)

Login Information – User XYZ

Date	Time
Thursday, April 24, 2003	6:50:32 PM
Thursday, April 24, 2003	7:41:39 PM
Thursday, April 24, 2003	7:44:39 PM
Friday, April 25, 2003	11:19:52 AM
Friday, April 25, 2003	12:09:44 PM
Friday, April 25, 2003	1:34:05 PM
Friday, April 25, 2003	1:37:52 PM
Friday, April 25, 2003	1:44:42 PM
Friday, April 25, 2003	4:57:11 PM
Friday, April 25, 2003	5:09:13 PM
Friday, April 25, 2003	5:17:01 PM
Friday, April 25, 2003	7:07:52 PM
Friday, April 25, 2003	7:30:10 PM
Friday, April 25, 2003	7:37:16 PM
Saturday, April 26, 2003	8:26:48 AM
Saturday, April 26, 2003	4:16:41 PM
Sunday, April 27, 2003	3:37:58 PM
Sunday, April 27, 2003	4:22:35 PM
Sunday, April 27, 2003	5:03:38 PM
Sunday, April 27, 2003	9:14:03 PM

Online Test Results – User XYZ

Exam	Result (%)	Date	Test Performance Comments
more_on_doping_test	91.00	Thursday, August 14, 2003	Excellent
more_on_doping_test_short	50.00	Saturday, August 16, 2003	Average
atomic_history_test	10.00	Friday, August 22, 2003	You have to put in more effort
atomic_history_test	0.00	Friday, August 22, 2003	You have to put in more effort
hydrogen_atom_test	10.00	Friday, August 22, 2003	You have to put in more effort
atomic_history_test	0.00	Sunday, August 24, 2003	You have to put in more effort
Radioactivity_test	10.00	Sunday, August 24, 2003	You have to put in more effort
binding_energy_test	0.00	Sunday, August 24, 2003	You have to put in more effort
Radioactivity_test	0.00	Sunday, August 24, 2003	You have to put in more effort
electricity_revision1_short	62.50	Tuesday, August 26, 2003	Average
electricity_revision1_short	81.25	Tuesday, August 26, 2003	Very Good
electronics_test1_short	7.14	Tuesday, August 26, 2003	You have to put in more effort
hydrogen_atom_test	0.00	Wednesday, December 03, 2003	You have to put in more effort
hydrogen_atom_test	0.00	Wednesday, December 03, 2003	You have to put in more effort
hydrogen_atom_test	0.00	Sunday, December 07, 2003	You have to put in more effort
hydrogen_atom_test	10.00	Tuesday, December 09, 2003	You have to put in more effort
hydrogen_atom_test	0.00	Thursday, December 11, 2003	You have to put in more effort
Radioactivity_test	0.00	Monday, July 05, 2004	You have to put in more effort
atomic_history_test	30.00	Tuesday, September 28, 2004	You have to put in more effort
atomic_history_test	0.00	Wednesday, September 29, 2004	You have to put in more effort

Table 11.5

Mid and End-of-Semester Results for Year 10 Science (2001 and 2002) for the Second Quartile.

Assessment type	Difference in the means#	Standard deviation (end-semester)	Standard deviation (mid-semester)	Effect size	Paired sample correlation
		Traditional learning group (2001) (N = 55)			
Knowledge	-4.43*	4.92	13.62	0.43	0.38*
Application	-5.81	28.51	18.22	0.24	0.16
		Blended learning group (2002) (N = 61)			
Knowledge	3.90	2.74	15.91	0.34	-0.03
Application	-2.81	21.47	20.66	0.13	0.13

Equals the difference in the means of the end and mid-semester exams.
* $p<0.05$.

In 2002, students in the second quartile did better than students of similar ability in 2001. There was a significant effect for the results obtained in the Knowledge section ($t(54) = 2.61$, $p<0.05$), with students achieving higher scores in the mid-semester than end-of-semester exams in 2001. This decline the result coincided with an effect size of 0.43. The results for this section were reversed in 2002, with an effect size of 0.34. Based on these results it is reasonable to suggest that web-based learning probably influenced students' performances for the Knowledge section. In 2002, the results in the Application section for this group improved in comparison to the students in this quartile in 2001. Even though the results declined in both years, the effect size was almost halved in magnitude from 0.24 in 2001 to 0.13 in 2002.

The paired sample correlation for the Knowledge results for this group was interesting. While in 2001 this measurement was positive and significant, in 2002 there almost no correlation between the two sets of results. This suggests that for students in the second quartile, their relative performance in the two exams were different. A similar analysis was carried out for the students in the third quartile (Table 11.6).