

A STUDY OF A NATION-WIDE PILOT PROGRAM IN SCHOOL MATHEMATICS

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ABSTRACT

A senior high school in Western Australia participated in the piloting of the National Mathematics Program initiative organised by the International Centre for Excellence. The opportunity to modify the school's Year 8 program and to implement change in the schools feeder primary schools occurred with the second stage of the pilot program's Transition Phase 1 and 2, implemented in 2007. This paper presents an overview of the research methodology and presents some of the findings.

INTRODUCTION

There is a change happening in many western civilisations in the way that we view the importance of mathematics in world leadership. The TIMSS (Third International Mathematics and Science Study 1995) and its successors (1999 and 2003) placed the United States, Australia and New Zealand well behind countries such as Singapore, Chinese Taipei and Japan. Business leaders in the United States expressed concern with ... increasing foreign competition especially from Asian nations and the decreasing interest in Science, Technology, Engineering and Mathematics among American students ... (Walters, 2005, p. 1) to prompt campaigns with the goal to double the number of graduates with bachelor's degrees by the year 2015.

In addition to Australia's position in International Benchmarks, the lack of consistency in curriculum outcomes across Australia was also being questioned. The Curriculum Corporation in its consultation draft National Consistency in Curriculum Outcomes (NCCO) and under the Schools Assistance Act (2004) required the States and Territories in Australia to implement changes in their curriculum according to the Statements of Learning either as part of their next curriculum review, if that occurred between 2006 and 2008, or before 1st January 2008. Equally important was the requirement that all States and Territories implement common testing standards, including a common national test by 1st January 2008.

The International Centre of Excellence for Education in Mathematics (ICE-EM) was commissioned to write a program for lower secondary students and primary students with appropriate textbooks and then administer the program Australia wide. After the first year (2006) in this pilot program, the first author realised that for this initiative to be successful the need for consistency with curriculum among our feeder primary schools was necessary particularly in the Outcome Number where mathematics staff at the high school had expressed over many years concerns about students' lack of skills and understanding in Number.

AIMS OF THE STUDY

The research reported in this paper addresses the content and activities in the pilot program textbooks – that is, whether a teacher would need to change his/her pedagogy when using the textbooks and whether the content has been levelled in sequential and appropriate stages for students and staff at one high school and three of its feeder primary schools in Western Australia – and whether there is an improvement in standards from adopting the new course of study.

RESEARCH METHODS

The research was conducted in three primary schools and one senior high school in a large country setting in Western Australia involving over 300 students and 10 teachers. Two of the primary schools are major feeder schools for the high school and the third fluctuates from year to year. Classes are of mixed ability in all the participating schools, and in the primary schools, students in Year 6 and 7 are mixed together in two of the schools and Year 7 in the third school. Three high school classes implemented the Year 7 program for their Year 8 students. This decision was made based on the

teachers' knowledge of past students' understanding of major concepts in Number. Calculators were not used in the schools implementing the program fully with an emphasis placed on teachers developing students' mental computational strategies.

This study employed qualitative and quantitative paradigms (mixed method research (Johnson & Onwuegbuzie, 2004) or fourth generation evaluation (Guba & Lincoln, 1989)) to investigate data. Western Australian Literacy and Numeracy Assessment (WALNA) data had been distributed to schools since 2003 and this data was used to make comparisons between students or groups employing non-experimental (Johnson, 2001) techniques over the course of this study. This was combined with observations of, and discussions with, students, the Numeracy Coordinator and teachers in order to conduct cross case comparisons and analysis in a natural setting. The study utilised student and teacher questionnaires and compared content between the textbook authors and the K-10 Syllabus manuals in Western Australia and then examined how both of these aspects related to the Statements of Learning for Mathematics (SLM) developed by the Curriculum Corporation (2006).

Questionnaires

The student questionnaire developed by Australian Council for Educational Research (ACER) (Ingvarson et al, 2004) was administered at the beginning of the study and again after six months when students were told to consider their mathematics education over the first half of this year. The aim was to map any changes in student attitudes to mathematics and learning between the student's previous learning experiences and the learning that took place in the first semester when the pilot program was implemented; either fully, partially or not at all. Four extra questions were included in this posttest questionnaire where students were required to respond to the positives and negatives of the textbook and pilot program. The teacher questionnaire Teacher Belief and Attitude Survey was developed in part by this researcher, in part from work by Nisbet and Warren (2000) and in part by work from the Queensland Government research project Teachers Enhancing Numeracy (2005). The first author used this survey to get an overview of the teachers' characteristics before the project was implemented. After six months, teachers were asked to respond to questions about the textbooks and pilot program.

Western Australian Monitoring Standards in Education (WAMSE) scores

Assessment tests for the WALNA program and the Department of Education and Training/University of Western Australia (DET/UWA) Year 8 testing program had been developed to reflect good classroom practice and written to cater for the diverse range of students in Western Australian schools. These tests provide students of all levels with an opportunity to perform to the maximum of their abilities. The development of the assessment materials ensures that there is no systematic bias associated with such factors as gender, culture or geographic location. Student WAMSE scores were used to investigate changes in student's achievement and progress over two testing periods. For the primary school students this involved Years 5 and 7 and for the high school students between Years 7 and 8.

RESULTS

What changes in pedagogy are required by teachers in order to address the content in the new textbooks?

Teacher responses were generally positive about the content in the textbooks. Responses that were negative from teachers were concerned with the difficulty of the course for low achieving students and the difference between the Curriculum Framework Outcomes and the content in some chapters in the books.

The textbooks introduced many Number concepts through diagrams including the number line and this process assisted many students to understand operations. The number line became the favoured approach of all teachers in the development of students' understanding of place value and equivalence of fractions and decimals. Through the textbook content, professional development for teachers was provided on developing the mental strategies outlined in the K-10 Syllabus document and the key points in the Statements for Learning in Number.

Mental strategies were not taught by teachers prior to this pilot program but by the end of the course, those teachers who formally taught the strategies felt positive about the benefits of introducing these skills. The mental strategies used in the textbooks and the problems with students' understanding of basic facts the first author observed in this study are not new to mathematics learning (Baroody,

1984; Brumfield, & Moore, 1985; McCrae, 1985; Curriculum Framework, 1998; Grossman, 1985) but they may have been overlooked due to time constraints and the availability of calculators. What was evident, at the beginning of the study, was that the majority of students in Years 6, 7 and 8 did not have the skills nor had any formal instruction on how to calculate mentally. The first author believed this was a concern but found it difficult to convince some teachers of the benefits of introducing appropriate techniques to overcome these problems. The problem was highlighted at the high school where teachers, making a concerted effort to instruct students on mental strategies as outlined in Transition 2A, spent longer than expected and desired in the teaching of Number. Mental strategies are outlined in the Curriculum Framework, SLM and K–10 Syllabus as essential skills but the Aspect Use a calculator for all four operations became the dominant force in these classrooms. These observations had been reinforced in discussion with teachers at numerous meetings during 2006 and 2007. It should not be left to one year-group of teachers to introduce mental skills in the classroom. The process needs to start at home then through K–8 with each year building on the skills and reinforcing them in numerous situations and activities. There are many activities and strategies and professional journals *Mathematics in School* and *Teaching Children Mathematics* written to assist teachers wanting to learn more about ways to help student calculate mentally (Ball, 2007; Baroody, 2006; Becker et al., 2007; Morgan, 2000; Thompson, 1999; Yang, 2006).

In a high percentage of classes, students responded favourably to the interactive nature of the activities in the textbooks and in general, students were supportive of their peers and provided assistance when required. The notion that back to basics cannot be fun, was dispelled in the study with many students eager to participate in number games and improving their recall of basic multiplication facts through practice with the 10 x 10 multiplication table.

In many cases, the way the textbooks introduced topics or dealt with content was new to teachers, and on many occasions, teachers made favourable comments on the approach used by the textbook writers (Becker et al., 2007). The writers believed that there should be “a strong emphasis on understanding basic ideas and mastery of essential skills” (p.vi). This belief was shared by all teachers in this study with activities and worksheets design to ensure students work toward mastery of the 10 x 10 multiplication table. The books were written so that they did not require the use of a calculator, but mention was made that “some teachers may feel that it is appropriate for their students to undertake activities that involve calculator use”. AND “teachers should use it flexibly and supplement, where necessary, to meet local requirements and the needs of their students” (p.vi).

In six of the nine classrooms in this study, the calculator was not used in the teaching program, with teachers developing students’ mental strategies as outlined in the Transition textbooks, the Western Australian Curriculum Framework and the Statements of Learning for Mathematics. When calculators were used in classrooms, their use contributed to decreased mental recall and created misconceptions about order of operations.

This study highlighted the difficulty of implementing change in school classrooms, with teachers not always willing to explore modifications to their teaching and learning program nor to accept constructive advice from a colleague in regard to teacher misconceptions. This will be an issue for curriculum leaders in schools when the process of implementing a National curriculum commences in Australia. There are many changes that teachers must implement in their teaching programs but from my discussions with some teachers, this may not occur. The Curriculum Framework has provided teachers with the flexibility to implement any program in mathematics under the guise that the teacher is the best person to know what the student needs. While this notion is not being disputed, it is also creating problems. In discussion with one teacher, the comment was made that low achieving students would not have the intellectual capacity to do mental calculations, so the best that could be done for these students is to provide them with the opportunity to succeed with the calculator. If the first author could have taken this teacher into some of the primary school classes and let her observe the educational support students and students well below the Benchmark happily applying mental skills and succeeding, then it may have made her reflect on the comment she made.

The introduction of concepts in Number outlined in the textbooks were closely aligned to Getting it Right Numeracy (GIRN) and First Steps Mathematics strategies in Western Australia. This approach assisted some teachers with positive change in their pedagogy and provided effective professional development for teachers on GIRN principles. When used in classrooms it did impact positively on students’ understanding of concepts and this was reflected in the students’ WAMSE scores. GIRN professional development needs to be accessed by all teachers in primary and high school and its principles used by teachers. Currently there is a tendency for teachers to introduce algorithms without students understanding why a process works. Multiplication and division of fractions is a high level skill that most primary and high school teachers would not attempt, yet within one hour, two classes of Year 6 and 7 students had mastered the process without any algorithm being introduced. The process

relies upon full class participation and discussion. The process would not be effective in classes where students sit passively completing worksheets.

Teachers felt that the first year had its problems but were keen to try it again next year. As one teacher stated:

For the first time in a long time there was a structure to a mathematics program. It's not perfect as I would like to see more problem solving type activities but if you combine most of what is asked in the books with extra work it is great.

This response was similar to those expressed by the high school teachers with all three teachers eager to redo the program the following year adopting many of the approaches used to assist students understand and enjoy mathematics.

Textbook content (intended curriculum) and its suitability for students?

Students generally responded favourably to the course and textbook with more primary school students recording positive comments. Responses that were negative were from, low achieving students concerned with the difficulty of the course and high achieving students responding that the course and textbook was too easy and that they were not challenged by their teacher.

It was evident from the students' comments that games were a contributing factor in students' enjoyment of mathematics. These games were not computer based but simply hands on activities involving cards, counters and dice. They were used in the classroom to help students retain and improve their basic skills.

Games and group activities from the textbooks were used to reinforce Number concepts with great success in some classrooms with students making positive comments about their enjoyment of mathematics. When group work was not employed or students were not permitted to share their experiences as was evident in one classroom, students responded negatively about their learning and enjoyment of mathematics.

Students accepted the textbooks introduced into the classroom. A comment made by one teacher, that students found the textbooks boring, was not generally supported. Not all of his students found the textbooks boring; many felt comfortable with the textbook and saw it as step to higher mathematics. Other students responded that there was an opportunity to review the type examples and introduction when they did not understand the exercise. It is not possible to produce a textbook that would suit all learning styles and prior knowledge. It would be anticipated that some students would find sections easy while others would find the same sections difficult. This would also apply to worksheets. Many students in other classes made negative comments on the number of worksheets used in the classroom preferring to have a neat package provided by a textbook. The best that teachers can do is to provide opportunities and extension for all students by developing a learning program where students feel happy, engaged, inquisitive and self disciplined. The worst that teachers can do is to have student sit at their desk, read the introduction and then do the exercise as was noted in this study.

Has the content in the textbooks satisfied Western Australia's Outcomes Based Education system at each outcome level according to the child's development stage?

To answer the question the Curriculum Framework (1998), Curriculum Framework Curriculum Guide – Mathematics (2005), Curriculum Council Progress Maps (2005), Working Version K–10 Syllabus (2007) and K–10 Syllabus (2007) was used to illustrate the Outcomes as identified by the Curriculum Council at each year of school. A comparison was made with the Statements of Learning for Mathematics (SLM) developed by the Curriculum Corporation (2006).

The concepts and processes used in the Transition textbooks in Number are very important for students in Year 6 and 7. They replicate the K–10 Syllabus and the Curriculum Corporation's (National) Statements of Learning. Schools should use Transition 1A/B in Year 6 and Transition 2A/B in Year 7 or a similar program that will address the content outlined in these books. Schools with low ability mathematics students would need to modify the content found in Transitions 1A/B to a simpler form and spend more time on reinforcing concepts. To help students understand the Number concepts, teachers should implement processes involving diagrams, the number line and use area concepts to help students arrive at their own rule. This is particularly important for low achieving students in schools. Algebraic symbolism will need to be introduced in primary schools so that students are able to meet the requirement of the SLM and assist them with the New Courses of Study in high schools.

In December 2007, the Department of Education and Training provided teachers with the K–10 Syllabus. The confusion that emanated from their release was the perceived notion that Outcomes Based Education was being replaced and after 10 years, the State had returned to its original curriculum content driven system. The new WA Education Minister Mark McGowan however, reported that the Syllabus was an aid for teachers (Hiatt, 2007, p. 8) and “dismissed suggestions there might be confusion in the education of students taught according to the syllabus and those who were not” (“Syllabus Returns,” 2007). After investigating the K–10 Syllabus in mathematics the first author is of the opinion that there will be differences between students’ learning between teachers using the K–10 Syllabus and those following the Curriculum Framework. The syllabus document specifies content at different years of schooling. It is linked to the SLM and this implies that many of the concepts that were taught in Year 8 and 9 will now be taught in Year 6 and 7. These include algebraic symbolism and formulae. My disappointment was that the Syllabus document in mathematics was not mandated. Many of the problems that were experienced at the high school revolved around the vast differences in students’ content knowledge for each academic group of students. For example in one primary school, the teacher covered concepts involving powers. This is a Year 9 high-level concept and while the academically able students were able to understand the concept, the majority of students in the class were working below the state average and 25% were below the Benchmark. The K–10 Mathematics Syllabus is a good document. Apart from the minor errors that have been noted, its use should be employed in classrooms throughout Western Australia but caution should be exercised. Not all classes and students will be working at the same year level. The class in a Band 2 (low socio economic) primary school should not attempt the same work as a class in a Band 5 (middle–high socio economic) primary school. This then highlights another problem with a National curriculum. There is no assurances a family moving interstate or within the state would transfer to another school in the same band nor have teachers working on the same topic or Outcome.

The books should not be used as the only source of information. While Number content was closely aligned to the K–10 Syllabus and Statements of Learning for Mathematics this was not the case with Space and Chance and Data. Algebra was introduced at Year 7 in Transition 2B, but more would be required if the Outcomes addressed in Statements of Learning for Algebra are to be covered. Teachers implementing this National program in the future would need to be mindful of these differences and be prepared to provide extension work for high achieving students. Prior to extension work being undertaken, teachers need to ensure students have satisfied the statements relevant to each outcome. In many instances students who made the comment the work was easy were not able to demonstrate the Outcome in the tests. Low achieving students would need extra help to ensure they do not continue to be left behind.

Was there is an improvement in student’s performance based on WAMSE scores testing when the National pilot program was adopted?

WAMSE scores were analysed from UWA/DET and WALNA testing in this study. At the high school, student results did not show any difference between the 2004/2005 and 2006/2007 cohorts. Teachers were happy using the textbooks and employed many of the diagrammatic approaches used to help students learn mathematics in Number. Teachers believed that student behaviour and attitude to learning, parental involvement and absenteeism impacted on students’ Achievement and Progress in mathematics. With any program these issues would always occur.

In the primary schools, the results varied between classes and schools. The most noticeable change occurred at one primary school were students’ Progress, in the two classes that used the pilot program, had GIRN support and actively involved me in the Teaching and Learning Program, was Moderate or higher. In the class that did not have this support or use the textbooks, the majority of students showed Very Low or Low Progress but this could be attributed to the low number of students having a Year 5 and Year 7 WAMSE score.

There is a need to be cautious when analysing WALNA scores and making generalisations from one test. Student numbers can affect percentages in Achievement and Progress; some students may not be feeling well (as had been noted by teachers in the study) and therefore perform poorly in the test. There is an opportunity for students to guess the correct answer for multiple-choice questions and therefore achieve higher scores than might be expected. At one primary school, the strong union support from teachers had resulted in many students not sitting the WALNA test in previous years and this impacted on the statistics used in the study from this school. Administration at schools needs to exercise caution when distributing these tests to teachers prior to the actual student testing time. Teachers had the opportunity to examine the test questions and consciously or subconsciously review or introduce similar types of questions days before the test. A further concern was reported by one

Principal who made comment that on one testing period a number of years ago, the teacher supported the students to excess during the testing time. This resulted in higher than expected WAMSE scores. For subsequent testing periods, it had a negative impact on the boxplots in Data Club and Progress graphs in First Cut.

CONCLUSION

When the first author initiated this study with the high schools feeder primary schools, the intention was to have consistency in the mathematics program to help teachers at the high school extend on what had been learnt rather than redo the mathematics that may or may not have been done depending on the primary school. This has not been achieved fully because not all teachers were willing to implement change in their teaching program.

Through the schools' involvement in the ICE-EM program, outcomes include:

- the professional development of nine teachers and their exposure to content that has been outlined in the Statements of Learning for Mathematics and the K-10 Syllabus has been enhanced.
- improvement in teachers' knowledge in developing students' mental strategies.
- pedagogical change in some teachers with a shift toward a constructivist perspective.
- renewed teacher interest and enthusiasm for mathematics.
- teacher misconceptions have been addressed.
- a strong partnership with the primary schools students, the administration and teachers has been established.

The information obtained from teachers and students along with observations and discussion with the stakeholders in this study, has provided accountability information to the ICE-EM program coordinators Principals and the District Director. The strength of the Pilot Program has been the consistency of Outcomes covered by the majority of teachers and this has been observed in the Year 8 student cohort in 2008 where students have demonstrated greater understanding of Number concepts. Teachers involved in the pilot program and using the textbooks either partially or fully during 2007 have continued using the textbooks in 2008 and where required have made positive changes in their teaching program utilising the most appropriate textbook for their students.

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