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# TEACHERS EXPLORING NUMERACY LEARNING & TEACHING IN THE EARLY YEARS OF SCHOOLING

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*This paper discusses the effectiveness of the professional development model used by the Catholic Education Commission of Victoria Numeracy Strategy Project. The project used an action research methodology within a team structure to explore numeracy learning and teaching. Three case studies of early years teachers indicate that the teachers developed some important insights about numeracy learning and teaching in the early years of schooling and provide evidence of reported change in beliefs and practice.*

## INTRODUCTION

Numeracy Education is an important focus of education systems across Australia. The Federal Government National Goal *that every child leaving primary school will be numerate, and be able to read, write and spell at an appropriate level* (MCEETYA, March 1997) has provided impetus for developing strategies to improve numeracy learning and teaching, particularly in the early years of schooling. For example, The NSW Department of Education implemented the Count Me In Too Project in 1997, and the Victorian Department of Education has recently begun the Early Numeracy Research Project.

During Term 4 of 1998, the Catholic Education Commission of Victoria (CECV) undertook the Numeracy Strategy Project. The project gathered 50 teachers, six university academics and several Catholic Education Office (CEO) consultants from across Victoria for the purpose of gaining knowledge about numeracy learning and teaching in action research contexts. In so doing, the project aimed to provide professional development for teachers who might take on leadership roles in forthcoming years. It was also anticipated that, as a result of the project, the teachers would provide advice for the CECV in the development of a strategic plan for numeracy education in Victoria. The project participants formed six teams which each investigated a different aspect of numeracy learning and teaching. This paper reports on the Early Years Team who researched numeracy learning and teaching in the early years of schooling (K-4). In particular, the effectiveness of the model of professional development adopted by the project is considered through exploring two questions: Did the model result in teachers developing insights about learning and teaching numeracy in the early years of schooling? Was there any evidence that this approach to professional development may result in changing teachers' beliefs and practices?

## AN APPROACH TO PROFESSIONAL DEVELOPMENT

The model of professional development designed for the Early Years Team was built on four principles: (1) for changes in beliefs and practices to occur, teachers must first recognise an aspect of their practice is problematic; (2) for professional growth to occur resulting in changing teachers' practice, knowledge and beliefs, teachers need opportunities to experiment and reflect; (3) teachers engaged in a process of change benefit from the support of colleagues and mentors; (4) professional development needs to be driven by teachers' individual concerns, interests and the realities of their classrooms.

In light of these four principles, an action research methodology within a team structure model of professional development was developed. The team approach was adopted to enable teachers to explore issues of mutual interest and concern, to support each through a process of change and to provide opportunities for collective reflection and planning. In a similar way to the Maths in Schools approach (Montgomery, 1995), an academic with expertise in the research area joined the team as a research partner and mentor.

Clarke & Peter (1995) argue the importance of teacher experimentation and reflection in enabling professional growth to occur. The project thus adopted an action research methodology, using the cycle of plan, act, observe, reflect. This methodology provided opportunities for teachers to experiment and reflect on an aspect of numeracy education of individual interest and concern in the reality of their own classroom. Sparrow & McIntosh (1998) highlight the significance of professional development being driven by teachers' concerns, interests and the realities of their classrooms. They argue that teachers must be empowered to identify and meet their own needs for professional development, that they must have ownership of the research and the decision making and that professional development must be relevant to the experience of the teacher and their teaching situation.

In order to assist the teachers to recognise an aspect of their practice that may be problematic and in need of change, the teachers were each asked to identify and write about a dilemma they had faced when teaching number to young children. Such case writing, as proposed by Judith Shulman, "enables a teacher to describe a critical incident or dilemma encountered in personal practice. Collaborative reflection on the writing enables a teacher, and colleagues who read the case, to understand and interpret the described practice and thus to propose action for change or improvement" (Western Melbourne Roundtable Innovative Links Project, 1997, p 29). Cobb, Wood and Yackel (1990) conclude from their research that it is the problems and surprises which teachers encounter in their own practice that give rise to opportunities to re-organise beliefs. Therefore, to enable change, teachers must first perceive their current practice as problematic, and then search for new beliefs and practices to overcome the problems. Identifying and reflecting upon a dilemma assists this process.

### **THE EARLY YEARS RESEARCH TEAM**

The Early Years Research Team formed as part of the Numeracy Strategy Project comprised nine teachers drawn from five schools across Victoria, an academic and a CEO Mathematics Consultant. Two teachers belonged to a Melbourne school, while the others taught in four country schools, three of which were situated more than 2 hours from Melbourne.

The team met initially for two days to: explore issues of mutual concern; to reflect on a problematic aspect of their practice identified through writing a dilemma faced when teaching number to young children; to develop a team research question and individual research goals relevant to their particular teaching situation; and to participate in professional development activities related to number learning in the early years of school. The team considered the stages in children's early number learning, strategies for assessing children's understanding of number, the role of visualisation in early number learning, the use of ten frames and other activities and games for supporting early number learning. The Early Years Team developed the following question to provide a framework for their collective research about numeracy learning and teaching in the early years of schooling:

*How can we effectively support young children's development of number concepts?*

During the six-week period in which the teachers researched in their classroom, either the academic or consultant visited the teachers in order to discuss their research and future courses of action. At the conclusion of the research period, the team met in Melbourne for a further two days. During this time, the team members shared the results of their individual research, discussed the findings, reflected on the effectiveness of the learning that took place in their classroom as a result of the strategies and activities that were implemented, identified any key insights gained about children's early number learning, and developed a set of recommendations for effectively supporting young children's development of number concepts. The teachers then produced a written report about their individual research projects.

## CASE STUDIES OF THREE TEACHERS

The following descriptions outline the experience of three teachers in the Early Years Team. Pseudonyms for each person have been used for the purpose of this report. The case studies describe the dilemma that lead to each teacher's research goal, a brief description of their action during the research and any insights identified about learning and teaching numeracy in the early years. Comment is also made about any evidence of change in the teachers' beliefs or practice.

### Geraldine

Geraldine taught a multi-aged K/1 class in a rural city in the Western District of Victoria. She has more than 25 years teaching experience, is a *Numeracy for All* tutor and a member of a district numeracy team. Geraldine was very enthusiastic about mathematics education.

Geraldine described her dilemma in the following way:

In teaching young children number, some regularly confuse the digits and write 16 for 61, even though they may say sixteen. Other children have no difficulty at all and readily transfer the concrete work to the abstract. I was interested initially to investigate children's place value understanding, particularly with 'teen' numbers, in my prep/one class. In thinking about this, it occurred to me that in preparing learning activities, we may place limits on our expectations of how far children can go with number. I found myself asking: How far can my children go with number? What is their related understanding of place value? If I take away the limits of my expectations, will I give children the opportunity to develop their understanding of number, in a way that may not have been possible before? My dilemma thus broadened considerably to become one associated with young children and large numbers. I was now asking, "What are the numbers young children can deal with?"

Having reflected upon this dilemma, Geraldine developed the following action research goals: to investigate how exploring large numbers contributes to children's development of number concepts; and to develop and consolidate place value understanding, especially teen numbers.

Geraldine began by assessing the smallest and largest numbers known by her students. She was surprised that many children knew about very large numbers. She discovered that although the children knew large numbers, few children could correctly write numbers beyond 99. Their attempts were linked to the sound of the number, rather than the place value conventions of our numeration system. Geraldine then began to explore large numbers with her class using house numbers and Outer Space as a context. Calculators were also used. Eventually, Geraldine introduced place value work using pop sticks, Multibase Arithmetic Blocks and numeral cards. By the end of the project, Geraldine was amazed with the Year 1 children's ability to write and read 3 digit numbers. She was also pleased that several Prep children were writing and reading two and three digit numbers. In summary Geraldine wrote:

It is important that we don't limit our expectations. I was constantly amazed and delighted by the differing abilities the children showed. They could do things I wouldn't have anticipated. They all grew in their understanding. We may need to consider this more seriously in determining number curriculum for children in the early years. Children can respond to open-ended, co-operative activities, some place value work and most importantly, the opportunity to explore larger numbers.

It is evident that Geraldine now believes that she should not limit her class to the exploration of two digit numbers. She found that many children knew about and were interested in much larger numbers. This gave her the opportunity to explore place value ideas in a much richer way resulting in the children learning about the conventions of reading and writing two and three digit numbers. As a result of this project, Geraldine now believes she is a more effective teacher:

In all I feel that this project has been very valuable. It has made me a better teacher through having a set focus to work on and by being specific in my questioning and understanding of how children learn. I certainly valued the input from the other teachers in my group and have a renewed zest for teaching mathematics next year.

### **Lisa**

Lisa has more than ten years teaching experience. She taught a Year 3&4 class in a Central Victorian rural city. She is a *Numeracy for All* tutor and a member of a district numeracy team. Lisa described her teaching dilemma as follows:

During the year I have observed some of the children in my classroom portray a negative attitude towards maths. I felt that these children had this attitude for one of two reasons. 1. due to a lack of self esteem. While a second group struggle in their understanding of maths problems. Some of these group members are interconnecting.

Lisa reported that her prime objective for this action research was to initially identify and then to focus on these children within the mathematical classroom environment. Her action research goal was: to develop in children the ability to apply their mathematical knowledge to real life situations.

Lisa used both open ended questions and the Pupil Perception of Effective Learning Environments in Mathematics (McDonough, 1995), to identify students with a negative attitude towards mathematics. These students became the 'target' group. She supported these children closely as they engaged in problem solving activities relating to two upcoming school events, the school sports and the school fete. The problem solving activities usually related to money and measurement. Lisa reported that by the end of the project the confidence of the target group had increased, they began to spontaneously make connections between mathematical ideas and were receiving encouragement from their peers. She gained some interesting insights into the way in which children believe they most effectively learn maths:

A significant proportion of the children felt they learnt a new concept more effectively if they were provided with the opportunity to manipulate some kind of materials during the initial teaching time. While in contrast to this the children who have developed more sophisticated problem solving skills are able to tackle the problem with their head, pen and paper.

Lisa reported that her practice had changed. She was now convinced about the importance of spending time talking to children and listening to their interaction. She concluded:

I found this (experience) to be very rewarding. I especially discovered that I obtained so much information about children's maths learning by simply talking to them and listening to their interaction with peers.

### **Kathleen**

Kathleen taught a Year K/1 class in a Northern Victorian rural city. She has more than 25 years teaching experience and described herself as nearing retirement. She was a member of a district numeracy team, but regretted the time this leadership role took away from her classroom teaching.

Kathleen described her dilemma in the following way:

After many years of teaching, I have always had considerable difficulty in achieving satisfactory results in the teaching of automatic subtraction facts. To do this I have always taught the relationship between addition and subtraction. In doing this I was aware that my current children were capable of all addition strategies, e.g.  $9+6=15$ . To establish where the children were currently "at" I wrote  $15-6=$  on the board and asked the children for the answer. I then asked 'how' they came to that answer. Some responses were "I counted backwards," " $10-6=4$  therefore  $9-6=3$ ." However, only three children were able to 'think' this way. Others said they would use their fingers and counters.

As a result of reflecting on her dilemma, Kathleen developed the following action research goal: to develop ways of ensuring a complete understanding of the inter relationship between addition & subtraction in year 1 children.

As part of her action research, Kathleen introduced a new teaching strategy. She provided the children with *ten frames* and counters and used visualisation as a means of developing an understanding of number. The children used the *ten frames* to explore the different combinations for a given number. Kathleen also encouraged children to use the *ten frames* to find missing addends in equations. Eventually, the children began to say, "I don't need those frames any more," and were able to satisfactorily find the missing numbers. Kathleen also used games such as dominoes and snap with cards displaying different combinations of a given number to assist children learn number combinations. As a result of her research, Kathleen discovered:

that the children need a strong understanding of numbers...they need to move from concrete objects to the visual and finally automatic recall....(Previously) I tried to move them to automatic recall without a thorough grounding in the visual aspect.

Kathleen also concluded that questioning individuals about 'how' or 'what' was an extremely important aspect of assessment. This was now an essential aspect of her practice.

The three case studies indicate that these teachers developed some insights about numeracy learning and teaching in the early years of schooling. They also provide evidence of a reported change in beliefs and practice on the part of the three teachers. It was apparent that the teachers' individual research goals related to an aspect of their practice that was shown by their teaching dilemmas to be problematic. Thus, the teachers clearly had ownership of the research and decision making throughout the project. It was also clear that the teachers valued the opportunity to discuss possible actions with the academic and other members of their team. Geraldine explained, "I certainly valued the input from the other teachers in my group." The actions that the teachers implemented related directly to their research goals and were often closely related to activities discussed during the initial professional development phase.

### **KEY INSIGHTS GAINED ABOUT CHILDREN'S EARLY NUMBER LEARNING**

One important aspect of this professional development project was the opportunity and expectation that the teachers reflect upon and discuss the insights they had gained about children's number learning. Therefore, the teachers and academic in the team gathered together for one day to reflect upon and discuss the outcomes of their research. The interest and enthusiasm for what had been learned was very high and the teachers were very keen to discuss the implications of their insights and suggest further causes of action.

Table 1 describes the insights the teachers gained about aspects of children's early number learning considered during the project. It is clear that this model of professional development resulted in all nine teachers developing insights about learning and teaching numeracy in the early years of schooling. The insights are a comprehensive list. They relate to teacher expectations, affective learning, assessment, teaching strategies, curriculum, learning activities and professional development. The teachers were also able to use their insights to form a useful set of recommendations about learning and teaching numeracy in the early years of schooling. This was a stated aim of the Numeracy Strategy Project.

*Table 1*  
*Key Insights Gained About Children's Early Number Learning*

Aspect of Teaching & Learning	Insights Gained About Children's Early Number Learning
Teacher Expectations	It is important not to limit the children's opportunities to develop number concepts through low teacher expectations. The children proved over and over again that they could do a lot more with number than we expected. Limitations should not be placed on the number range with which children are working.
Affective Learning	It is important that students develop a positive concept of themselves as mathematicians in the early years. This enables students to have the confidence to take risks as part of learning.
Assessment	It is important for teachers to have specific knowledge about children's understanding of number in order to support their learning effectively. In order to achieve this, teachers must spend time talking to children about the strategies they are using to solve problems. Written work samples do not provide the necessary information. It is the conversations with children that really inform teachers. The stages in children's development of arithmetic strategies provide a useful framework for considering children's arithmetic strategies.
Teaching Strategies	<p>It is important to make the aspects of mathematics being explored explicit for students so that their attention is focused on important mathematical ideas. It is important for teachers to highlight the important mathematical ideas discussed by students during sharing times.</p> <p>The use of small groups in mathematics classes helps children develop confidence and provides important opportunities to discuss mathematical ideas.</p> <p>It is important to include opportunities for students to reflect on the mathematical ideas they have been exploring. An important question is, "tell me what you have learnt".</p> <p>Children like to use manipulatives when exploring new mathematical ideas. They find this very helpful. These may be both physical materials and visual images. It is essential to provide these opportunities.</p> <p>Visual imagery is an important aspect of number learning. <i>Ten frames</i> proved very helpful.</p>
Curriculum	<p>The development of number sense must be a major focus of early years maths programs.</p> <p>There needs to be a major focus on the development of number combinations (such as all the number combinations for 8) in the early years of schooling. This is important for developing number sense and powerful flexible arithmetic strategies for problem solving. The project team trialled a number of activities that were found to be successful in this area.</p> <p>There is a need to focus on backwards counting in the early years. Children have particular difficulties with counting backwards from numbers greater than 20 and less than 100. Backwards counting sequences bridging the tens prove particularly difficult.</p> <p>It is important for children to have the opportunity to explore the meaning of mathematical terms and understand the application of words such as total and difference in a mathematical context. Children need opportunities to make these connections for themselves.</p>
Learning Activities	<p>It is important that mathematics activities are relevant and purposeful by being linked to community events. This helps children become more confident and motivated to learn.</p> <p>Problem solving activities support the development of children's number sense.</p> <p>It is vital that children have the opportunity to use oral language to support their number learning. Students need to constantly discuss their mathematical ideas and explorations with each other and the teacher.</p>

Games were an important strategy for developing children's understanding of number. It is important to use games in a focused way.

It is important to encourage children to estimate and predict when solving problems and then confirm their predictions.

Professional Development It is essential for teachers to have the opportunity to engage in professional discussion about mathematics. This has proved to benefit our teaching enormously.

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## CONCLUSION

The model of professional development used by the Early Years Team as part of the CECV Numeracy Strategy proved to be effective. Indeed, the experience was personally rewarding for the teachers involved. At the conclusion of the project, the teachers reported that they were highly motivated about mathematics teaching, had gained many insights about effective learning and teaching and in some cases felt professionally renewed by the opportunity to research and engage in professional discussion about their experiences and findings.

The project resulted in all nine teachers developing insights about learning and teaching numeracy in the early years of schooling. They were able to clearly articulate their findings and the implications of these findings for learning and teaching numeracy. They also developed a set of recommendations for effective mathematics learning and teaching in the early years of schooling that has potential relevance beyond these teachers' personal experience. The case studies of three teachers provide evidence that this approach to professional development may also result in changing teachers' beliefs and practices.

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