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## **An exploratory case study using an expert learning process designed to promote number sense in a year 6 classroom**

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**AN EXPLORATORY CASE STUDY USING AN EXPERT  
LEARNING PROCESS DESIGNED TO PROMOTE  
NUMBER SENSE IN A YEAR 6 CLASSROOM**

**By**

**Paula Mildenhall, B.Ed (Hons.)**

**A thesis submitted in partial fulfilment of the requirement of the  
degree of Master of Education at**

**Faculty of Community Services, Education and Social Sciences**

**Edith Cowan University**

**October 2005**

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## USE OF THESIS

The Use of Thesis statement is not included in this version of the thesis.



## ABSTRACT

The purpose of this study was to explore how an expert learning process may be beneficial in developing number sense in Year 6 students. The expert learning process was a set of reflective prompts designed to include questions that expert learners consider. I chose to focus on the development of number sense due to its centrality in today's mathematics curriculum; and as it was a more specific topic, it made the task more manageable for this relatively small study.

I used a case study method as this was an exploratory study and I was interested in gaining in-depth, rich material about one setting. The setting was a Year 6 class from a primary school in the Perth metropolitan area, and the study lasted for two school terms. The data collection method used a mixed paradigm designed in order to strengthen internal validity, although the predominant approach was qualitative.

Using qualitative data collection it was found that by engaging in the expert learning process, the students were prompted to reflect on their learning at various times throughout the number lessons, thus beginning to behave as self-regulated learners. The expert learning process also made the students more motivated in their attitudes towards the mathematics lessons, and after reflecting on the prompts provided, the students were at times directed towards more effective learning strategies.

The class teacher's teaching style was found to be extremely important in affecting the outcome of this study. Her transmissive teaching style meant that she did not perceive the students' reflections as important and therefore the learning environment was not influenced very much by these reflections. The students were powerless in this situation and had to accept the fact that their learning activities did not change greatly.

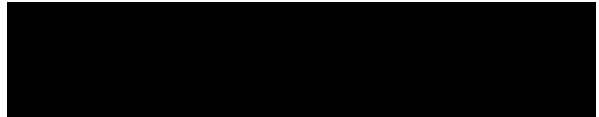
The study was designed to find out if the number sense performance of the Year 6 students improved through using the expert learning process. To investigate this I took a quantitative approach using a number sense test, which had been used in

an international study, and focused on analysing if there was any increased number sense performance. The results showed that there was no significant improvement in average number sense performance. It is important to note that the reason that number sense was not developed may have been due somewhat to the teacher's beliefs about mathematics. In this study the teacher did not believe that development of number sense should be the focus of her teaching. This again, reveals the importance of the teacher's role in guiding students to learn effectively.

## DECLARATION

I certify that this thesis does not, to the best of my knowledge and belief:

- (i) Incorporate without acknowledgement any material previously submitted for a degree or diploma in any institution of higher education;
- (ii) Contain any material previously published or written by another person except where due reference is made in the text; or
- (iii) Contain any defamatory material.



24/01/2006

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# CHAPTER 1: INTRODUCTION

This chapter commences with the background to the problem and then establishes a conceptual framework which describes the research study. Statements, which outline the significance and purpose of the study, follow this. At this point I state my research questions and finally provide a definition of some of the important terms used in the thesis.

## 1.1 Background

Research into how students learn is now well established. With the departure in education away from behaviourism (Thorndike, 1924) and towards perceiving the learner as an active participant (von Glasersfeld, 1990; Herrington, 1992) the cognitive revolution has continued. Information processing models created during this revolution attempted to analytically identify the cognitive steps that learners take, “heavily influenced by computer metaphors” (Silver, 1987, p. 34).

The ramifications for mathematics education were immense. In mathematics education the student thinking process became far more important and early pioneers such as Polya (1957) began identifying general steps which would support students when problem solving. The term *metacognition* was gradually introduced to “describe knowledge and thinking processes that monitor and assess learning” (Herrington, 1992, p. 4). The awareness of what this term means and its importance in the educational research community has steadily grown.

It was problematic initially to find one clear definition of this. In Herrington’s research (1992) he used the definition below by Meichenbaum (1985):

as to what a person knows about his or her cognitions (i.e. consciously aware of the processes and being able to relate them in some way) and to the ability to control these cognitions (e.g. planning cognitive activities, choosing among alternatives, monitoring and changing activities. (p. 412)



With the student expected to be able to problem solve, and understand mathematical processes it became important that these aspects were analysed and as a result of this, cognitive-metacognitive frameworks were established (Garofalo & Lester, 1985). The logical next step was then to “incorporate metacognitive aspects into mathematics instruction” (Garafalo & Lester, 1985, p. 172). This focus on making children aware of metacognition became important in supporting children learning mathematics (Herrington, 1992; Schoenfeld, 1992; Silver, 1987; McLeod, 1990).

Herrington (1992) found benefits as a result of increasing metacognitive awareness in the primary mathematics classroom. He found that students undergoing a program designed to increase metacognitive awareness and teach learning strategies “displayed a greater extent and quality of learning strategy awareness, more confidence towards learning mathematics and a higher performance on standardised tests of mathematical performance” (1992, p. iii).

Another line of research, which blossomed in the cognitive revolution focused on an analysis of the approach taken by experts (Glaser & Chi, 1988; Chase & Simon, 1973). This research focused on the common steps taken by experts in various fields. Ertmer and Newby (1996) proposed one such model, which identified the processes which expert learners follow. They identified that experts are aware of the cognitive strategies that they themselves possess, can identify strategies that are required for a task and if they do not have the required strategies, they are knowledgeable in how to acquire these. When completing the tasks they self-regulate and reflect on these tasks. As well as cognitive strategies, which earlier studies such as Herrington’s (1992) focused on, they also identified the importance of motivational and resource management issues. The widening focus has begun to be identified as important for characterising effective learning. Researchers have specifically identified that motivational issues and students’ beliefs need to be built into metacognitive models (McKeachie, Pintrich, Lin, & Smith, 1986; Silver, 1987; McLeod, 1990; Cobb, 1990; Dart et al., 2000). Other researchers have identified the resource management issues as an important component of effective learning (Dunn, Krimsky, Murray, & Quinn 1986; Burke & Burke-Samide, 2004).

Ertmer and Newby (1996) outlined that students in classrooms should be made aware of their expert-learning model in order that they improve their

effectiveness in their approaches to learning. The research quoted on the areas of metacognition, motivation and resource issues in the classroom led me to speculate that there may be worthwhile benefits to students being made aware of Ertmer and Newby's model (1996) in today's primary mathematics classroom.

There has been no research conducted previously on raising students' awareness of this model in the classroom to my knowledge, and Ertmer and Newby (1996) had found little empirical evidence of teaching students about how to develop reflection skills. I decided, therefore, to begin consulting past research that contained related aspects, in order that I could evaluate how students could be made aware of this model.

I felt it worthwhile to look back at Herrington's research (1992). In his study he divided his objectives into four areas. The first three areas were concerned with children's beliefs in mathematics. In his fourth area, however, he tried to increase metacognitive awareness in the classroom, which is a concept central to the expert learning model. To do this he used "techniques that involved concept mapping, using a think board, self-questioning and writing" (p.iii). In Herrington's study he saw the strategy awareness of the students increase but other aspects such as "mathematical performance measures" were not statistically significant. (p. 249)

I felt, however, that this approach had clear benefit to the children and that it would be worthwhile to use the same self-questioning technique in order to encourage children to think in a way that expert learners would. Herrington's (1992) research was an important catalyst for this proposed study. He used a variety of self-questioning techniques to increase metacognitive thinking; some of the techniques that he used were a "learning poster...." (p. 331) "learning check.... and lesson check" (p. 333). The poster provided a general reminder for students to "monitor learning" (p. 331). The learning check was a set of prompts to be read by the students before they embarked upon their mathematics learning and the lesson check was for students to evaluate their mathematics lesson. I decided to adapt Herrington's work and instead of using a variety of methods to increase metacognitive awareness, I decided to simplify the process and make the expert learning model integral to every lesson. Ertmer and Newby, who created the expert learning model, had concluded that "reflections do not have to have to take the form of questions, but self-questioning can facilitate the reflective process" (1996, p. 19). This assertion, along

with Herrington's findings, inspired me to create an expert learning process. I also consulted reliable research about cognition/metacognition (Herrington, 1992; Meichenbaum, 1985; Garafalo & Lester, 1985; Naglieri & Johnson 2000) motivation, (McKeachie, Pintrich, Lin & Smith, 1986; Silver, 1987; McLeod, 1990; Cobb, 1990; Dart et al., 2000) and resource management issues (Dunn, Krimsky, Murray, & Quinn 1986; Burke & Burke-Samide, 2004). The expert learning process included a reflective prompt with a section for planning, monitoring and evaluating as Ertmer and Newby (1996) assert that expert learning undertakes this self-regulatory process.

To complete this expert learning process I decided to include a plenary session into each lesson as I felt that it was important students discussed their answers to the reflective prompt in class discussions. While taking a radical constructivist theoretical stance, I believe that the social setting is greatly advantageous to learning. This viewpoint is not contradictory with constructivists' views, who agree that social interaction is an important vehicle for learning (von Glasersfeld, 1998) and it was possibly only early supporters of discovery learning who saw learning taking place individually from a series "of assignment cards" (Dienes, 1967, p. 145). Instead of individually embarking on a lonely voyage, the assertion "that human learning presupposes a specific social nature and process by which children grow into the intellectual life around him" (Vygotsky, 1978, p. 89) needs to be embraced in the classroom. Research is finding that in mathematics education, reflective discourse provides students with effective learning opportunities (Askew, Brown, Rhodes, Wiliam, & Johnson, 1997; Whitenack, Knipping, Noringer, & Underwood, 2004; Trafton & Thiessen, 2004). Burton (1993) also asserts that this type of discussion as been very effective as it allows the teacher to listen to the students' present understanding and thus guide future activities.

It is necessary to point out that while some of the above research relates directly to the role of metacognition in purely problem solving activities (Polya, 1957), other researchers designed their metacognitive framework as "relevant to performance on a wide range of mathematical tasks, not only classified as problems" (Garofalo & Lester, 1985, p. 171). Ertmer and Newby's model (1996) also referred to learning generally. This is important because today's mathematics classroom

includes a wide range of mathematical activities not just problem solving as in the accepted mathematics education sense.

The last adaptation from Herrington's research was to focus on number sense performance rather than the whole of the mathematical curriculum. Before providing a rationale as to why this focus was chosen, it was necessary to define what I mean by the term 'number sense'. It is an emerging definition often used alongside the term 'numeracy'. The term numeracy often encompasses a much broader range of meanings. Number sense is more specific and has been described by McIntosh, Reys, Reys, Bana, and Farrell, (1997) as:

a person's general understanding of number and operations, along with the ability and inclination to use this understanding in flexible ways to make mathematical judgments and to develop useful and efficient strategies for managing numerical situations. (p. 3)

Number sense was chosen as the focus for this thesis due to its emerging importance in the mathematics curriculum. Developed societies are demanding a highly educated workforce; with the ability to solve problems, and work in an ever-changing world so many mathematical educators are calling for students to be numerate citizens. For this to happen they are calling for number sense to have a central focus in today's mathematics curriculum (Sowder, 1990; Yang & Reys, 2001). With advanced technology and the common use of calculators the efficient rote learning of written algorithms no longer has much purpose. As Swan (1996) asserts:

Technology has been wholeheartedly embraced by employers and very few would expect that an employee would complete tedious calculations using written methods. They would rather employees use the most efficient method, whether it be calculator or mental computation. One reason for teaching mathematics to children is to prepare them for the real world. (p. 54)

Number sense was also a more specific topic, rather than trying to consider the whole mathematics curriculum and this made it more manageable for this relatively small study.

The Western Australian *Outcome and Standards Framework* (Department of Education and Training, 2005) has identified number sense as a central component of its mathematics curriculum, and has asked schools to organise their curriculum so

that students have opportunities to “use numbers and operations and the relationships between them efficiently and flexibly” (2005, p. 32). Certainly, if society is to be able to apply the learning about number, then schools need to be promoting true understanding of number, so that members of society will know how to solve problems presented in the real world.

It is important that research plays a role in providing guidance for teachers as to “what type of curricular and instructional approach will best foster the development of number sense?” (McIntosh et al., p. 5). Through researching number sense, there have been many important factors already identified in planning number lessons. These include teachers providing lots of estimating activities (Thornton & Tucker, 1989) and mental computation opportunities (Askew et al., 1997).

I was interested in assessing whether the reflective prompt that I have assembled may theoretically support number sense development. Through consulting the literature on latest opinions and research findings, the reflective prompt’s use in this domain was ascertained.

The expert learning process was identified as being particularly useful for number sense development in the following areas:

- Reflection by the learner (McIntosh et al., 1997).
- Teachers understanding students’ thought processes (Askew et al., 1997; Sparrow & McIntosh, 2004; Gravemeijer, van Galen, Boswinkel, & van den Heuvel-Panhuizen, 2004).
- Reflective discourse (Askew et al., 1997; Whitenack et al., 2004; Trafton & Thiessen, 2004).
- Resource management (Trafton & Thiessen, 2004; Mulligan, 2004; Gravemeijer et al., 2004; Sparrow & Swan, 2004).

Ertmer and Newby’s model (1996) is a generalised model of how expert learners gain success in any learning situation so it is not surprising that many of the approaches it suggested are reiterated in the opinion of mathematics educators as to how children will develop number sense. It is the focus of this research study to explore how the reflective prompt, which was inspired by the model of *Expert Learning* (1996), may promote number sense.

Underpinning this study is the theory of radical constructivism. This implies that teachers must embark on the long process of teaching for understanding by the individual learner (Piaget, 1962; Bruner, 1966; von Glasersfeld, 1990). If the desired aims of creating students who can use their learning in the real world and be confident with number is to be achieved however, then this ‘understanding’ must also be robust enough for students to apply this understanding quickly, mentally and in everyday situations. This robustness may emerge from students developing understanding and then practising solving problems on a regular basis in mental computation settings (McIntosh et al., 1997; Sowder, 1990). A result of this may be that children learn to quickly solve mental computation problems in the classroom, achieving automaticity (Gerston, 1999). This ability aids them even further in solving more difficult mental computation questions. This does have similarities in its product to behaviourist aims of the past (Thorndike, 1924) but the process, which creates students who confidently work with number, is quite different. This process is one where the learner personally constructs the knowledge for him/herself (Bruner 1966; Piaget, 1962; von Glasersfeld, 1990). This does not mean that teachers do not have an important role, but it does mean that if teachers are trying to develop number sense in their students, one of the important components of their teaching must be to provide opportunities for radical constructivist learning. McIntosh et al., (1997) emphasises the teacher’s role as encouraging numerical concepts to be “individually internalised” (p. 44).

The reflective prompt had been created to remind the student to focus on all the concepts to be learned and to link previous knowledge with this focus. This process of linking previous understanding with new understanding is very important for learning (McIntosh et al., 1997). Good and Brophy (1997) also make this point in asserting that “students learn through a process of active construction that involves making connections between new information and existing networks of prior knowledge” (p. 397).

Theoretically, therefore, the reflective prompt may have potential in developing students’ number sense. It was of interest to explore what happened when the reflective prompt was integrated into a number classroom.

## **1.2 The Conceptual Framework**

The conceptual framework in Figure 1 describes the research study. I created this framework with radical constructivist learning theory underpinning the study and then focussed on Ertmer and Newby's model (1996) which highlighted the characteristics of expert learners. The intention then was for a process, which enabled the learner to be made aware of this expert learning model and would promote number sense, to be implemented in the primary number classroom. The reflective process has been identified in the model. A series of self-questions were created for children to reflect on their work during number classes. This process had two components to it. The first component has been described as a reflective prompt, and it includes adaptations of Ertmer and Newby's (1996) own examples of questions that experts may consider. The second component was described as a final whole-class discussion. The final part of the conceptual framework reflects how this process, which took place in the primary number classroom, was to be observed. In this way the effects on the students' learning could be analysed and described.

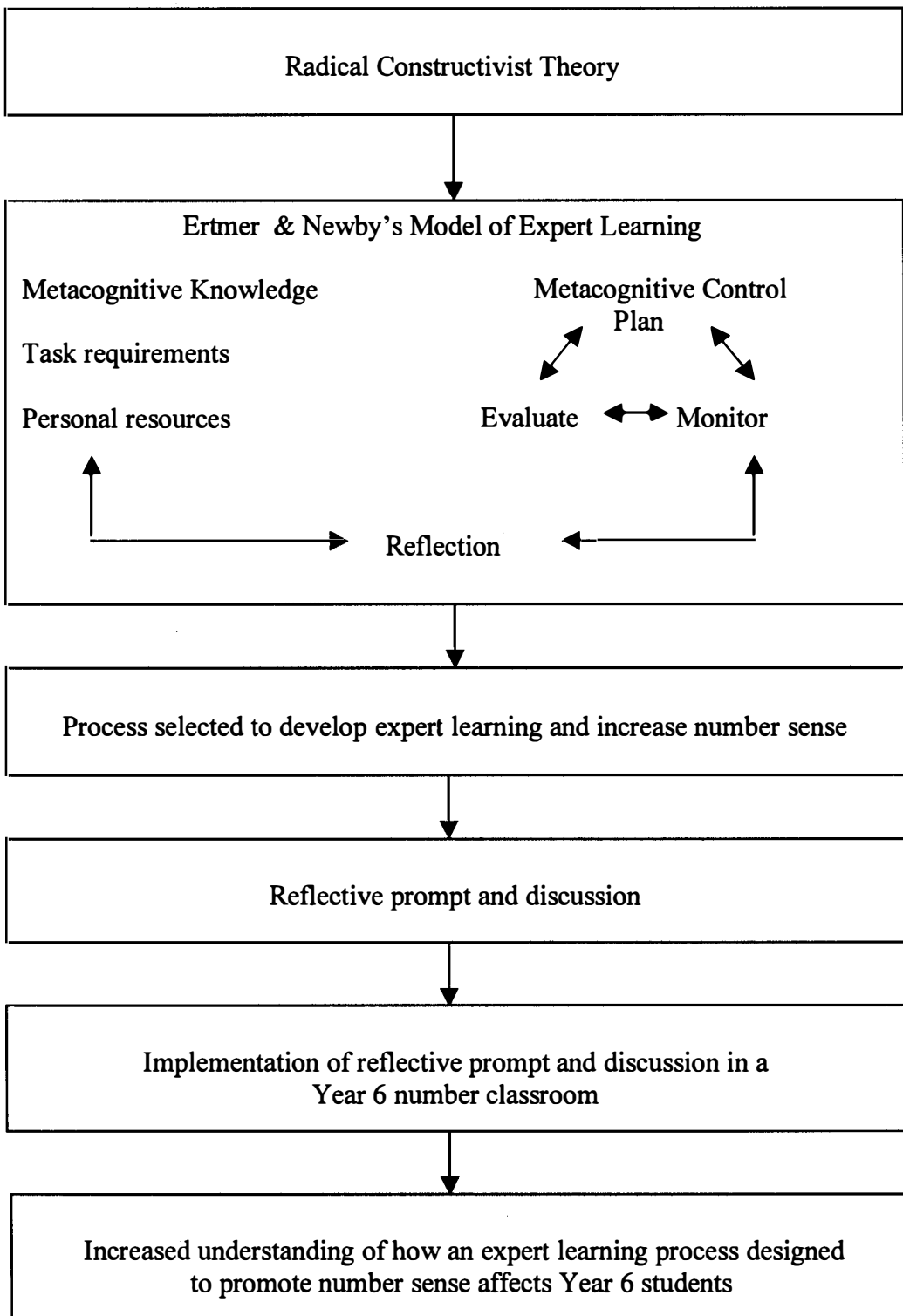


Figure 1. Conceptual framework for the study



### 1.3 The Significance of the Study

If children are actively engaged in their own mathematics learning, and learn with understanding, they may be able to apply the mathematics learnt in school for use in society. It is therefore, a worthwhile aim to conduct research that explores how to create manageable approaches to guide children so that they may be encouraged to become more engaged in the pursuit of learning with understanding, so becoming numerate citizens of the future.

In Western Australia the *Progress Maps* (Curriculum Council, 2005) now requires that children approach mathematics in a way described as Working Mathematically (p. 18). This includes the expectation that students will “use mathematical thinking processes... reason mathematically... apply and verify” (p. 13). There is a distinct connection between this approach and the steps considered in the Ertmer and Newby (1996) model. Ertmer and Newby’s model places a strong emphasis on the use of a variety of strategies and resources. They recognise the importance of planning and consider reflection as vital to successful learning. The ‘working mathematically’ document also perceives learning to be an active process; learning with understanding rather than a transmissive view of learning.

If children begin to self-question and learn with understanding as perceived in the Ertmer and Newby model (1996) and Von Glasersfeld (1992), they will be working mathematically as envisaged by the *Progress Maps*. This research could therefore indicate to teachers, who have previously shied away from teaching children to think mathematically, how to begin this process.

## **1.4 The Purpose of the Study**

The purpose of the study was to explore the effects on Year 6 students' learning about number when using an expert learning process. A set of prompts was designed to include questions that expert learners consider. The Year 6 students had to consult this and reflect on their personal answers during each mathematics lesson. As this was a case study design it was planned so that rich intensive data was collected.

## **1.5 Research Questions**

The first research question had been intentionally designed to allow for the predominately exploratory nature of the study. I felt that it was very important not to anticipate the findings but document whatever effects were demonstrated. I also wanted to record all the effects, including attitudes and beliefs. The reason for recording these effects was due to the expert learning model documenting the learner from a broad perspective. The second question reflects my belief in the importance of developing number sense and allows for a quantitative judgement as to whether the performance increased. These results should also support the findings from the first research question.

1. What were the effects on Year 6 students of using an expert learning process designed to promote number sense?
2. Did number sense performance of the Year 6 students improve through using an expert learning process?

## **1.6 Definition of Terms**

I have presented a list of definitions of terms and concepts in the order that they are encountered in this thesis so that they can be referred to as needed. In providing these definitions I have tried to provide clarity for those terms used where the meanings may be ambiguous.

### ***Expert learning process***

This process refers to a series of prompts created by myself so that students ask themselves questions that expert learners would consider and it was created using the *Expert Learning Model* (Ertmer & Newby, 1996). The questions were presented in a written format for the planning and monitoring stage as in Appendix C and named ‘reflective prompt’ and I adapted it slightly as time in the classroom went by and this is included Appendix D. The final self-questioning section took the form of a whole class discussion asking the students to reflect back on the learning process asking such questions as, what they learnt, and what they still did not understand, as in Appendix E, and this was identified as a final whole class discussion.

### ***Reflective prompt***

The written reflection conducted in the planning stage of the class and midway through the lesson was defined at the reflective prompt as in Appendix C. The children referred to the sheet containing the questions that expert learners may consider in the planning and monitoring stages as their reflective prompt. They filled in this in their number lessons, at the beginning and midway through the lesson.

### ***Number sense***

I have used the definition provided by McIntosh et al. (1997) as I used their number sense test, which was used in an international study for analysing number sense levels, and they have engaged in extensive research into number sense. Number sense refers to a “person’s general understanding of number and operations along with the ability and inclination to use this understanding in a flexible way to make mathematical judgments and to develop useful and efficient strategies for managing numerical situations” (McIntosh et al., 1997, p. 3).

## ***Understanding***

When I began this study I took ‘understanding’ to mean having a deep conceptual knowledge of concepts. It was only when I was in the field did I realise that understanding can mean different things to different people. Skemp (1976) provided definitions that allowed me to contrast one idea of understanding with another.

### ***Relational understanding***

Skemp identified relational understanding as ‘knowing what to do and why’ (1976, p. 20). He gives further explanation indicating that in relational understanding “learning relational mathematics consists of building up conceptual structures” (p. 26).

### ***Instrumental understanding***

Skemp identified instrumental understanding as “rules without reasons...for many pupils and teachers the possession of such a rule and ability to use it was what they meant by understanding” (p. 20).

### ***Transmission teaching***

I have used Askew et al., (2004) definition as it fits neatly into the behaviour that I have described as transmissive teaching in this thesis. The report (Askew et al. 1997) on effective numeracy teachers has been important in the design my study; particularly in identifying the links between the aims of the expert learning process and what effectively develops number sense. It is therefore very appropriate to use this.

The transmission orientation is marked by a clear separation of teaching and learning, with the emphasis on the teaching. Teachers disposed toward this orientation see students as dependent upon the teacher for gaining access to mathematics. The transmission orientated teacher, regards herself as primarily responsible for the learning. The student’s role in the class is subordinate to that of the teacher. (p. 177)

### ***Discovery methods teaching approach***

An appropriate description of a discovery methods teaching approach is Askew's (2004) definition.

A discovery orientation emphasises the responsibility of the learner in coming to know mathematics. This leads to valuing student independence above direct teaching. Emphasis on the student as an independent learner carries the presupposition that what is to be learned has not been taught. (p. 177)

This chapter has provided a general background for the study. A more detailed analysis of the relevant literature is covered in the next chapter.

## CHAPTER 2: LITERATURE REVIEW

As I had made the decision to conduct this case study using both quantitative and qualitative data collection it was appropriate to refer to literature which related to both quantitative and qualitative designs. The following literature review was conducted in order to inform my research study. The areas of focus included the designs of previous studies, methodology as well as theoretical underpinnings. I also conducted a review of the literature “to assist in the formulation of the research question” (Johnson & Christensen, 2004, p. 62).

It was necessary to initially explore why the expert learning process that I have created was theoretically sound and worth researching in the classroom. It was essential to find out how this area had been researched in the past and the conclusions that had been reached, in order to ensure that the research would be worthwhile. As this case study was created using findings from a few different areas of research, it differed from other studies, so I identified the important research studies that focused on the main components of my study and reviewed the literature in each of these. The purpose of this was to “identify established knowledge and, more important, ... develop significant, new questions” (Marshall & Rossman, 1995, p. 31). It was imperative that I identified how the areas explored by other researchers would contribute to my research focus.

It was also important to locate this research in a “body of theory” (Marshall & Rossman, 1995, p. 28). As this study is researching learning, it was especially important for the purposes of this study to define learning. I identified that radical constructivist learning theory would underpin the study; therefore some exploration of the important theorists’ beliefs was necessary in order to validate this decision.

I then considered research undertaken on the subject of raising metacognitive awareness, as metacognition is an inherent part of expert learning and there is a large body of significant mathematics research in this area. Past research on raising metacognitive awareness was informing the study, so it was significant to review these developments. Particular attention was paid to those studies that used a prompting approach to raise metacognitive awareness and those that covered the

curriculum area of mathematics education. It needs to be acknowledged that there are differences between expert learning as defined by Ertmer and Newby (1996) and metacognition, and these differences were outlined.

It was also necessary to review research on expert learning to understand how studies began analysing expertise in individual domains and then began to find that while an expert at one field did not automatically become an expert in another, there were commonalities between how different experts become proficient in their different areas of expertise (Brown, Bransford, Ferrara, & Campoine, 1983). This realisation that the capabilities of the expert learner can be identified is beginning to be used to benefit learning in the classroom. Various researchers are trying to raise students' awareness of the approaches that experts take in different curriculum areas and it is necessary to examine some of these studies in order to guide my own study.

Lastly it was important to explore what number sense is and why it is becoming a very important part of today's mathematics curriculum. Researchers have identified how it can be developed effectively in the classroom and have conducted research to identify the way forward. In this way it was possible to identify how the characteristics of the reflective prompt could support the development of number sense.

## **2.1 Radical Constructivism**

For this proposed research, radical constructivism theory underpins how I perceive the active construction of knowledge to take place and this theory has been central to the formation of the study. I believe that this theory should be the foundation of what true learning is and should be the goal of all primary mathematics classes. Unfortunately this is not always society's goal and where students are expected to recite transmitted facts in order to pass exams, students may simply be engaging in rote learning. This type of learning has been described by some as surface learning (Biggs & Moore, 1993). If society supports and rewards surface learning, children may not master mathematical concepts and in an age when calculators and computers have taken away the need for surface/rote learning, it seems futile to teach mathematics without understanding. This study focussed

therefore, on developing children's ability to learn as defined by radical constructivism.

If I am to make the assertion concerning the superiority of radical constructivist learning, then it is important to justify why this is the approach that will create children who have a true understanding of mathematical concepts. This conclusion was arrived at after considering how cognitive development takes place in the individual learner. Piaget is a useful starting point, as he made the important realisation that learning must begin with the child. He was sure that knowledge was not given to a passive observer; rather "knowledge of reality must be discovered and constructed by the activity of the child" (cited in Ginsburg, 1969, p. 14). As a biologist Piaget described the cognitive development of children in similar terms to his specialised field. He saw children, like all forms of life, to have the tendency to integrate structures and he classified this process as organisation. His second principle of functioning is adaptation. This relates to his observation that learners "assimilate or accommodate new information" (cited in Ginsburg, 1969, p. 19). Ausubel (1968) confirmed how crucial it is that the correct exposure to certain activities occurs for children to build up their own understanding. He explained that "by employing optimally effective methods of ordering the sequence of the subject matter, constructing its internal logic and organization, and arranging practice trails" (p. 153) we can promote effective learning. He saw a huge problem with children not fully mastering new concepts, as they have insufficient anchoring ideas. More recently, Burton (1993) supported making connections in children's learning asking, "where am I now" and "where am I going?".

From the above discussion therefore the teacher's role is not to "dispense knowledge but to provide students with opportunities and incentives to build it up" Glasersfeld (cited in Murphy, 1997, p. 3). Teachers then have to work in the classroom to facilitate learning. Glasersfeld further explained, "from the constructivist perspective, learning is not a stimulus response phenomena. It requires self-regulation and the building up of conceptual structures through reflection and abstraction" (cited in Murphy, 1997, p. 4). It appears extremely important in this theory that learning concentrates on the process. Von Glasersfeld followed on to explain, "learning is making sense of one experiential world. In this process, students' errors are seen in a positive light and as a means of gaining insight into



how they are organising their experiential world” (cited in Murphy, 1997, p. 4). Burton (1993) agreed with this concept of learning and asserted that the classroom has to become a place where being wrong is a positive experience. She perceives that children will only reveal their personal cognitive process if it is safe to do so. This means that children must not experience any negative consequences if they show a lack of understanding. It becomes apparent therefore that teachers need to engage students in “inquiry into worthwhile and meaningful questions, critical thinking about significant policy issues, and discussion of potential methods of solving real problems” (Good & Brophy, 1997, p. 404).

Finally it is important to make the point that although it is certainly true that in radical constructivism knowledge only exists in the heads of individuals, Glasersfeld’s theory does “not deny the role of social interaction – it merely stresses the obvious fact that others, society, language, etc. become known to the individual only by way of his or her interpretation of the relevant interactions” (Glasersfeld, 1998, p. 1). This was important as I was aiming for the reflective prompt to be part of a classroom, with the teacher teaching and fellow students sharing mathematical ideas rather than thirty-two individual students learning on their own.

## **2.2 Raising Metacognitive Awareness in the Mathematics Classroom**

It became clear to Garofalo and Lester in the early 1980s that “elementary students do not routinely analyse problem information, monitor progress or evaluate results” (1985, p. 169), and because of this they felt that it was important to focus on these aspects in primary mathematics. They presented a cognitive-metacognitive framework, which highlighted “key points where metacognitive decisions are likely to influence cognitive actions” and these included “orientate, organise, execute and verify” (p. 171). With these metacognitive actions outlined they called for more emphasis to be placed on metacognition, particularly in “instructional treatments” (p. 172). This view was reiterated by other mathematics education researchers such as Silver (1987), Schoenfeld (1992), and Herrington (1992).

In this research I began focusing on Herrington’s work, which attempted to raise awareness of the importance of metacognitive aspects in the primary classroom. Herrington (1992) conducted research, which considered student beliefs and

strategies for learning mathematics. His study included a yearlong learning program designed to teach metacognitive learning strategies. Some of the metacognitive materials that he used in this program were a learning poster, learning check, lesson check and mathematics check. These all used a self-questioning (prompting) approach, which encouraged the children to reflect as they progressed in their mathematics lessons. The results, analysed using ANCOVA, revealed that students undergoing the program displayed a slight increase in learning strategy awareness, although the higher performance on the standardised testing and the increased confidence towards learning mathematics was not statistically significant. I felt that it was worthwhile to conduct a predominately qualitative study, which extended Herrington's work, and provided a useful description of the effects on the students, which took place when such a study was conducted. Herrington identified that there would be benefit from further research and he felt that his study might have been more effective if it had included other strategies such as "anxiety reducing tactics and motivational skills training" (1992, p. 254). The current research study did include reflection on these affective areas so it was of interest to consider if this would impact on the outcome.

Other research has revealed that prompting had been effective in raising students' awareness of metacognitive issues (King, 1992; Lin & Lehman, 1999; Schoenfeld, 1992). In Schoenfeld's college problem solving courses he found that prior to the course 60 per cent of students stuck at the problems without considering other lines of inquiry; using few skills of an expert problem solver. Throughout the course he kept asking the students three questions to make them consider their actions. After the course was completed, fewer than 20 per cent of the students still behaved as a complete novice. It has to be noted that the success of these studies varied. Both Herrington's (1992) and Barry's (2002) research found statistically significant improvements in metacognitive strategy awareness but found that the increased mathematical performance was not statistically significant.

Research into diagnostic teaching methods showed that a program that involved intense discussion between pupils about their mathematics learning produced statistically significant gains in testing (Bell, 1993). Bell conducted a series of three experiments in which he investigated students' number misconceptions and how to remediate these. In his second experiment with fraction misconceptions, he

took two classes of 10- and 11-year-olds who had the same teacher and the similar mathematical experiences. The quasi-experimental method produced some worthwhile results. He asserted that these gains show the importance of immediate feedback to students and that the connection between “doing and learning” (Bell, 1993, p. 136) is vital for students to acquire. What is particularly pertinent for the current study is his opinion, which came from analysing the results of the research. He “suggests that metacognition, in the shape of pupils awareness of their learning process, is an important field for study and development” (p. 146).

Recent research is continuing to show effective gains in children’s mathematical performance after completing metacognitive training. Self-regulated learning strategies, which were taught to third-grade students, positively affected metacognitive awareness (Fuchs, Fuchs, & Prentice, 2003). Naglieri and Johnson (2000) conducted a small study on students aged between 12-14 years of age. This quantitative study encouraged students to improve their metacognitive awareness through discussion and results showed great improvements in the students’ cognitive ability.

Kramaski and Maverich (2003) have also identified benefits of metacognitive training. In their study of 97 seventh-graders the results revealed that students who were exposed to the metacognitive training and cooperative learning increased their mathematical performance in comparison to those students who were only exposed to a cooperative learning approach. This research suggests that metacognition is an important avenue for research, and since the expert learning model includes metacognition as a central component it supports the need for this exploratory study.

## **2.3 Expert Learning in the Classroom**

Researchers have been able to study the differences between expert and novices and they were able to identify certain things that experts do (Chi & Glaser, 1981; Chase & Simon, 1973). Daley (1999) recognised that expert nurses were different to novices; in particular they were more selective when finding out new information and decision-making was based more on patient needs rather than on transmitted information.

Bransford (cited in Brown, Bransford, Ferrara, & Campoine, 1983) made the important discovery that he was able to transfer some of the skills that he already possessed as an expert cognitive psychologist when trying to learn physics. Bruer (1994) asserted that some people are able to tackle new fields more competently than others. He terms these people as “intelligent novices” (1994, p. 9). He pointed out that while domain-specific knowledge is naturally important in the pursuit of learning something new; there are certain skills that they can apply to any task which lead towards expert performance. This is becoming increasingly important, as Brown and Palincsar (1987) stated:

in a scientific and technological society based on an increasingly complex and rapidly changing information base, a productive member of society must be able to acquire new facts, critically evaluate them and adapt to their implications ... There is considerable evidence that a sizable minority of school leavers , when they encounter college, the armed forces or the workforce lack the skills of the intelligent novice. (p. 83)

In the primary mathematics classroom if all students could approach new tasks as an intelligent novice or as an expert learner more students might achieve their potential in mathematics and continue to solve mathematical problems in the future when formal schooling is completed.

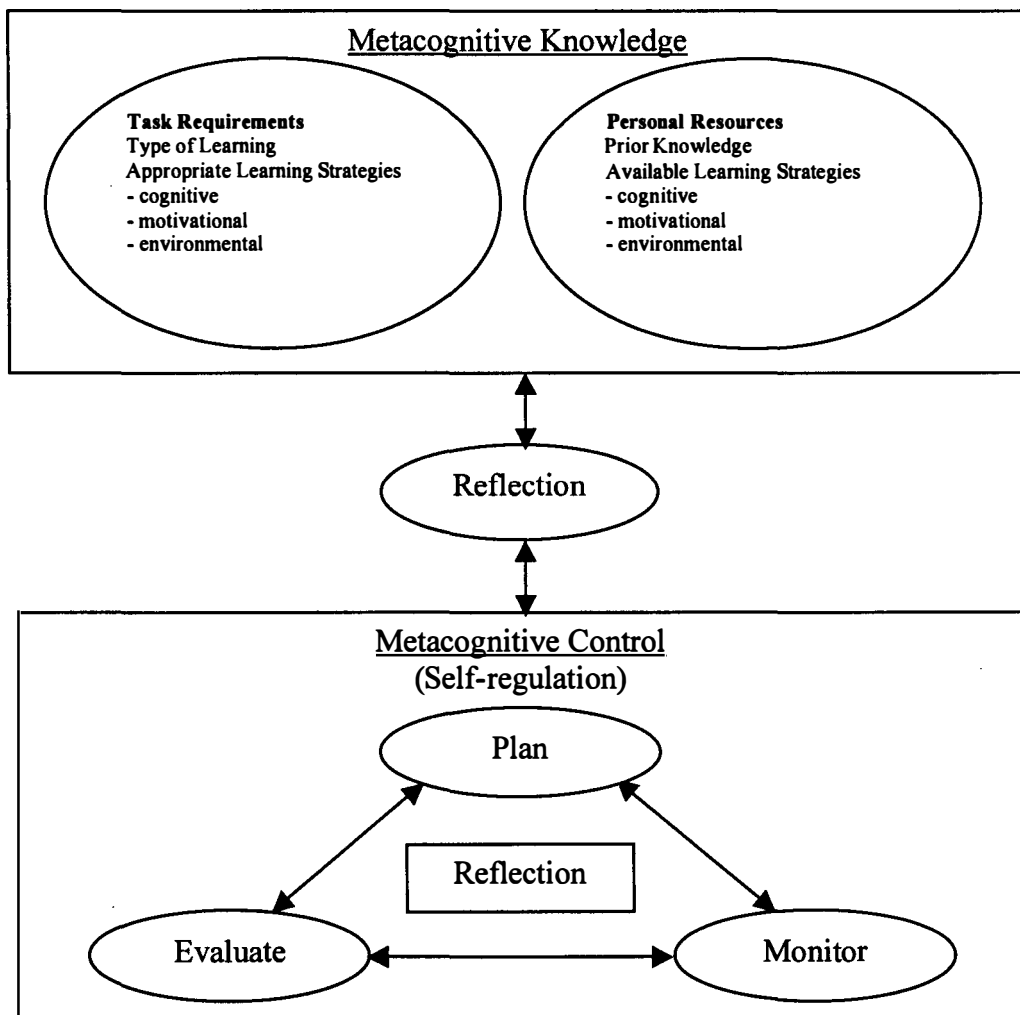
Brown and Palincsar (1982; 1987; 1989) conducted research in order to try to teach children to use expert reading strategies. The first piece of research started with “four seventh-grade students with homogenous learning problems”(1982, p. 10). This research used both quantitative and qualitative approaches. After an intervention to improve reading, using an approach which trained children to behave like expert readers, performance increased from 50 percent correct during baseline testing to 80-90 percent correct at the end of corrective feedback and strategy training. Qualitative results also reported that students began using strategies that they had never thought of using before. Further research was conducted using “regular teachers under conditions approaching those of the normal classroom” (Brown & Palincsar, 1987, p. 110). Teachers were trained and the study was implemented. The results were very similar to the laboratory experiments and formed a “baseline level of 40 percent, rose steadily during training and by the 15<sup>th</sup> day reached an asymptote of 70 to 80 percent correct”(1987, p. 113). These experiments were conducted in the real classroom and

improved reading comprehension in a mainstream class. This research program used both quantitative and qualitative methods to produce thorough and meaningful research that has directed my own design.

Ertmer and Newby (1996) also considered the contrast between expert learners and their less successful counterparts. They identified that:

Expert learners display planfulness, control and reflection; they are aware of the knowledge and skills they possess, or are lacking, and use appropriate strategies to actively implement or acquire them.  
(p. 1)

They wanted to show that there was an essential relationship between metacognition, self-regulation and reflection in expert learning and to do this they presented an expert learning model, which is shown in Figure 2.



**Figure 2.** Ertmer and Newby’s Model of Expert Learners (1996)

Due to its importance in this research study it is relevant to describe the components of the model in detail. It is much broader than the early models of the successful learner. Compared to Polya's earlier model of effective problem solvers (1957) which focussed solely on cognitive behaviour, this model illustrates how effective learning requires metacognitive knowledge of cognitive, motivational and environmental strategies. It also stresses that the learner needs to possess regulatory control of the learning activity through reflection on the learning process before, during and after the task has been completed. Ertmer and Newby drew on past research to create the model. The many different findings were brought together to present the complete picture of the expert learner. They emphasised the importance of the learner possessing a clear understanding of what the word learning means in each situation. For instance, is it rote learning or does the learnt information need to be applied in other contexts? This clarification of what learning actually means to students was also found to be important by researchers (Van Rossum & Schenk, 1984; Purdie, Hattie & Douglas, 1996).

The *Expert Learning Model* (Ertmer & Newby, 1996) also explained how expert learners implement appropriate regulatory strategies. Experts had been scrutinised and, rather than seeing learning as purely processing large stores of knowledge, how they regulate their learning is what makes them far more successful. The actual steps in self-regulation were identified and described in the *Expert Learning Model*. Expert learners start by accessing their knowledge stores and then they plan how they expect to accomplish their goals. As they proceed, the student is able to make constant fine-tuning in order to successfully complete the activity. It is important to appreciate that even before learners attempt a task they need to think about the requirements of the learning activity, their own personal ability to meet the task requirements and the "potential matches between the two" (p. 11). They need to monitor the learning act and this complex task needs to be conducted throughout the learning process. Finally after completing the entire task expert learners assess both the process of completing the task and the product achieved (Ertmer & Newby, 1996).

The model places reflection at the centre of successful learning. Reflection allows learners to make the most of their metacognitive knowledge during each stage

of the learning process. The learner reflects on his/her personal resources and task requirements before he/she begins the task. During the task there is continuous reflection of the various process of the learning task takes place and these stages were identified as the planning, monitoring and evaluating stages. It is important to realize that this activity goes on at both a conscious and an unconscious level. A final reflection of each learning activity is crucial. The expert learner evaluates the success of the task and the expertise of the learner is further enhanced as the learner stores the lessons learnt from the task, which will be utilised in future learning activities (Ertmer & Newby, 1996).

After creating this model Ertmer and Newby assert “there is very little understanding (and even less empirical evidence) of how this skill develops and how it can be influenced and improved” (p. 19). The researchers recommend that this model should be influencing the teaching process and they give clear indicators of how this could happen. They maintain that “extensive long term practice and feedback are considered critical for the development of expert learning” (p. 21), and that students should know how to “judge for themselves whether they understand, and know what to do when they need more information” (p. 22).

The impact of students reflecting on their academic work was also considered by McCrindle and Christenson (1995). In their quantitative and qualitative study, university students were “assigned to either a learning journal or scientific report” (1995, p. 167) which they had to complete during their lessons. Quantitative results show that the students who were assigned to complete the journal received better marks than the group who were asked to complete the scientific report and that this difference was significant.

The Ertmer and Newby model suggests that “self questioning can facilitate the reflective process” (1996, p. 19) and this self-questioning method was also used successfully by King (1992) to raise comprehension. Ertmer and Newby proposed that the “expert learner utilises reflective learning throughout an entire learning task” (p. 19), so it will be an important aspect of the research to encourage the children to reflect during, not just at the end of the mathematics tasks and that the self-questioning approach may have value.

## 2.4 Reflective Discourse

Past research has proposed that the children should be encouraged to discuss their thinking process with their peers through undertaking class discussion. Vygotsky's ideas (1978) are very important as they point to the benefits of social interaction. He differentiated between "lower and higher function" (cited in Nicholl, 1998, p. 1). Whereas our lower functions would develop even if the individual were isolated, he "saw our higher mental functions as developing through social interaction being socially or culturally mediated" (cited in Nicholl, 1998, p. 1). This perception holds important implications for the teacher, in that he saw teachers playing a vital role scaffolding the students' learning in the "zone of proximal development" (Vygotsky, 1978, p. 86). This is described as the "distance between the actual developmental level as determined through problem solving under adult guidance or in collaboration" (p. 86). More able children can also teach other children by operating in their zone of proximal development when they are involved in peer discussions. It is imperative to note that, while the ideas of Vygotsky are extremely significant, I have still placed the individual construction of knowledge at the forefront of learning as explained by Glasersfeld (1998).

Cobb, Boufi, McClain and Whitenack (1997) explored the introduction of reflective discourse into mathematical activities; the research had 18 children participate in a qualitative experiment. It analysed the effects of reflective discourse on mathematical activity. All 18 children developed more sophisticated counting methods by the end of his study. In their opinion "opportunities arose for the children to reflect on and objectify their prior activity as they participated in the discourse" (1997, p. 1). This definition of social discourse is one that I planned to use for my research study. Burton (1993) also advocates social discourse in the classroom as a vehicle for reaching consensus and encouraging children to work mathematically. She describes how through discussion, conflicting ideas can be discussed and the different possibilities celebrated. The teacher can encourage consensus in the group. Burton (1993) describes this as working with conviction, in pairs, in small groups and the whole class.

This type of social interaction was crucial for Brown and Palincsar's classroom research (1982; 1987; 1989) that acknowledged and incorporated the



Vygotskian idea of the zone of proximal development and used social discourse in a cooperative learning environment to improve reading ability. Research by Mevarech and Kramaski (2003) tested the effects of metacognitive training with or without cooperative learning. This quantitative experiment analysed the effects on high school students learning about linear graphs. On mathematical reasoning results, the cooperative groups did not perform any better than the students working individually but the cooperative group's fluency and flexibility in providing correct mathematical explanations did improve more than for the students working individually.

## **2.5 The Reflective Prompt and Number Sense Instruction**

There is clear agreement amongst many mathematics educators today that number instruction needs to focus on number sense (Sparrow & McIntosh, 2004; Thornton, 1989). The Western Australian *Outcomes and Standards Framework* (2005) has identified number sense as a central component maintaining that students need to “use numbers and operations and the relationships between them efficiently and flexibly” (p. 32).

It is important that educators have a good understanding of what number sense is and know what the number sense abilities of students are if we are to plan effective instruction. For this purpose it is useful to consider the study by McIntosh, et al. (1997) who “sought to advance the discussion of the value and means of developing number sense by gathering evidence regarding the current level of number sense of students aged 8, 10, 12, and 14 in four countries” (p. 6). Their study used a number sense framework developed earlier in 1992. The test was administered using a strict protocol. It is important to highlight that there could not be any “significant comparisons between the countries as the student samples were not representative of the school population of each country” (p. 13). The testing did reveal that in Australia the average “ten year old has a reasonable understanding of notation and place value of whole numbers and numbers with one but not two places of decimals. Understanding of fractions is limited to representations of simple fractions as parts of a subset of a set but not as points on a number line” (1997, p. 34). The results of this study are important for many reasons. One reason is that they show that children's number sense is often not as advanced as the teachers

generally believe. These tests surprised teachers, as they revealed the true level of understanding that the students were working at. This highlights the fact that the goals of mathematics education need to be clear for all. If society wants children to possess number sense, then it has to be clear to the whole community that this is the intention. Often teachers experience anxiety if standard algorithms are not taught to children (Duffin, 1991). They need to be reassured that although standards may appear to drop, as children are able to achieve more correct answers in the short term through following rules, children will benefit in the long run from being provided with activities which develop number sense instead.

Certainly research needs to play a part in order to provide guidance for teachers. They need to investigate “what type of curricular and instructional approach will best foster the development of number sense?” (McIntosh et al., 1997, p. 5). Through researching number sense, there have been many important factors already identified in planning number lessons. These include teachers providing lots of estimating activities (Thornton, 1989) and mental computation opportunities (Askew et al., 1997).

I am interested in assessing whether the expert learning process that I have assembled, inspired by Ertmer and Newby’s *Expert Learning Model* (1996), may theoretically support number sense development. Through consulting the literature on the latest opinions and research findings the reflective prompts use in this domain may be ascertained.

### **2.5.1 Reflection by the Learner**

Reflection by the learner is a “linking component in expert learning” (Ertmer & Newby, 1996, p. 15). They explain that “as a powerful link between thought and action, reflection can supply information about outcomes and the effectiveness of selected strategies, thus making it possible for a learner to gain strategy knowledge from specific learning activities” (Ertmer & Newby, 1996, p. 14).

Reflection of the individual when engaging in activities concerned with developing number sense has also been identified as very important. McIntosh et al. (1997) specifically identified that it was important that the teacher should create a “climate where reflection and evaluation are important elements in the work” (p. 44).

Trafton and Thiessen (2004) also state that in order to develop number sense, “teachers work to create a classroom community that supports reflection” (p. 115). In research by Askew et al. (2004) children’s inability to reflect on their personal learning experience and instead trying “to do what he believed the teacher expected of him” (p. 37) impaired learning.

### **2.5.2 Sense Making**

At the very core of the expert learning model are the learner’s “knowledge and use of effective cognitive strategies” (Ertmer & Newby, 1996, p. 9). This means that the learner needs to use specific strategies to enable success in the task. The expert learner may ask, “Do I understand what I am doing?” (Ertmer & Newby, 1996, p. 20). Ertmer and Newby assert that “students must be actively involved in their learning ... to judge for themselves if they understand” (p. 22).

Sense making has also been identified as an important aspect of teaching number sense to encourage students’ understanding. It has to be realised that “students who don’t understand that 1.20 is a representation of 1.2 that  $\frac{11}{13}$  is less than 1 and that 1000 is ten 100s must learn and remember a host of rules in order to deal practically with everyday numerical situations” (McIntosh et al., 1997, p. 4). It is therefore clear that instruction needs to “help children understand and make sense of mathematics” (Sparrow & McIntosh, 2004, p. 187) rather than following rules. One example of where instruction has been poor is in solving percentage problems. Dole found that students who “operated successfully in the domain of percent did so not because of their percent knowledge but because of their high level of number sense” (2004, p. 138). Dole asserts that in order that students come to be able to fully understand percent, then they need to be able to engage in four steps “interpreting ... representing ... symbolising and ... solving problems” (2004, p. 141). Trafton and Thiessen also believe that when sense making is the goal “learning often occurs through engagement in mathematically significant problems and tasks” (2004, p. 114).

It is important here to point out the essential nature of the teacher in developing this understanding. Askew et al., (1997) conducted a research study to observe effective teachers of numeracy. This term used in England is closely aligned to the more universal term of number sense. This study was representative of a range

of schools and used triangulation methods such as pre- and post-testing and interviews to increase its validity. They describe the effective teacher as one who teaches for understanding rather than expecting children to discover everything for themselves.

### **2.5.3 Understanding Students' Thought Processes**

The students being taught to be conscious of the learning process is vital to the *Expert Learning Model* (Ertmer & Newby, 1996). “Without reflection, learners may not learn to discriminate in applying procedures, may fail to recognise conditions when strategies may be appropriate for use and may fail to transfer knowledge and strategies to different tasks” (Ertmer & Newby, 1996, p. 17). The learner’s thought process is equally important in developing number sense. Despite the fact that the teacher plays a central role in effective number lessons, Askew et al. (1997) in a research study identified that effective numeracy teachers have an equal balance between teaching and learning, and it is realised that in order for teachers to teach number sense well they need to know their pupils. Askew et al. saw that effective teachers of numeracy use “continuous and varied means of assessment to build up detailed profiles of both class and individual student level” (1997, p. 11); quoting effective teachers making such comments as “every piece of work I do, I just keep a sheet like that ... and I write my own notes on there if a child has a specific problem” and “I use continuous assessment from talking to the children and from listening to what is going on and looking at the work that they are doing” (1997, p. 11). Sparrow and McIntosh agreed that “the observation, analysis and interpretation of critical incidents also appears to have a key role in comprehending what is happening and for planning a way forward for the learners” (2004, p. 185). These observations are often done instinctively by the teacher, throughout the lesson, either listening to the children, questioning them or observing their written work. Gravemeijer et al. (2004) argue for an instructional approach in which the “students build up on what they know” (p. 128) instead of trying to come to grips with strategies and procedures that are presented to them in a ready-made form when trying to improve number sense.

In an intervention program aimed at improving number sense of seven-year-olds who were considered to be low attainers, English researchers found that during

the course of observing children and teachers interacting, teachers did not probe carefully enough into the children's thinking. They felt that "recognising that students' interpretations of tasks and questions may not fit with what was intended suggests that teachers need to spend time finding out not only what has been learnt, but also how the student interprets the task" (Askew, Bibby, & Brown, 2004, p. 37). This important finding led the researchers to recommend that "this is an important area for further research" (p. 39).

#### **2.5.4 Reflective Discourse**

Reflective discourse is an opportunity for teachers to "facilitate genuine reflection ... guide students efforts until they become comfortable with the process and its benefits" (Gardner cited in Ertmer & Newby, 1996, p. 19). This "growth of reflection" (p. 19) is vital in the development of expert learning. This emphasis on reflecting through discourse is central in developing number sense. The interaction between the individual learner and teacher and peer group seems crucial. Teachers start with "pupils descriptions of their own methods and reasoning as starting points for engaging with numeracy concepts" (Askew et al., 1997, p. 5) and then direct the learners forward in their thinking using reflective discourse.

Whitenack et al. (2004) provided anecdotal evidence highlighting the importance of the teacher's role in interacting with the students and developing their number sense; promoting teaching that "capitalised on children's thinking and often used their contributions to generate investigations in which the students explored open-ended problems" (2004, p. 41). This following example of good practice in the classroom illuminated how directing discussion can support students' number sense development. Whitenack et al. (2004) provided the reader with a vignette describing where the researchers worked with a teacher who was simulating a candy cane factory. The children had to bundle the candy cane and through careful investigation, which included reflective discourse, the teacher was able to extend children's thinking about place value. The value of reflective discourse has been recognised by others. Trafton and Thiessen (2004) also believe that "class discussions or seminars in which children share their thinking" help to facilitate sense making in the child and helps to "develop understanding and strategies" (p. 115).

### 2.5.5 Resource Management

Ertmer and Newby's *Expert Learning Model* (1996) categorises a learner's awareness of "environmental strategies as part of the knowledge component of metacognition" (Ertmer & Newby, 1996, p. 10). They identify that successful completion of a task "must include the appropriate ... environmental strategies which would be instrumental in completing the learning task" (p. 12). In the literature there is little attaching number sense development specifically to when the study environment is suitable for the learner, but the role of resources within a classroom environment is mentioned.

Concrete material has an important role to play in supporting the student learning number sense. In the literature there is a clear emphasis on the teacher directing the classroom activity and this includes the resources. Whitenack et al. (2004) explain how to teach about number using a resource of candy cane and they provide pictures and multi-link blocks to simulate the candy. Counters are a way of developing early number concepts, forming arrays and different groupings (Mulligan, 2004). Number lines have great value in providing student with pictorial imagery of concepts such as ratio (Gravemeijer et al., 2004). Calculators also provide a valuable resource when developing number sense.

Sparrow and Swan (2004) recommend that for children to develop number sense and mathematical thinking using calculators they need to:

- learn how to use a calculator effectively and efficiently;
- help children make appropriate decisions between calculation methods at the point of use;
- help children build, connect and test mathematical ideas; and
- support rather than replace mathematical thinking (p. 60).

They believe that calculator use should be planned when appropriate and not only when children choose to do so. This is another example which shows the important part teachers play in developing number sense. If teachers make calculators as a "learning vehicle for children" it may support children so that "children will have the power to make informed and techno-appropriate choices about calculations" (2004, p. 61).

Teachers need to consider when resources are provided for activities rather than the children having access to all materials all of the time. If anything, number sense educators are moving more to the human resources of the classroom (Askew et al., 1997) rather than extensively relying on such manipulative as MABs , which can be awkward at times (McIntosh, 2004). Sometimes the resources can become the point of the lesson rather than the number concept. The reflective prompt may allow the teacher to identify if the resources that are available to the students are supporting their learning or not. If the students are finding resources actually making the learning more difficult, as can happen (McIntosh, 2004; Askew et al., 2004), this may be expressed in the reflective prompt. At the same time if the student needs some more resources such as concrete materials then this can also be expressed.

Ertmer and Newby's model (1996) is a generalized model of how expert learners gain success in any learning situation, so it is not surprising that many of the approaches it suggested are reiterated in the opinion of mathematics educators as to how children will develop number sense. It is the focus of this research study to explore how the reflective prompt, which was inspired by the Model of Expert Learners, may support teachers in providing the right activity at the right time to the right student. The aim of this would be to have each individual student in the class behaving as an expert learner. This is in many ways very idealistic but I believe worth pursuing. A classroom environment may be created where every individual child's thoughts and ideas are acknowledged within a cohesive group setting.

## 2.6 Conclusion

In sum it is clear from the literature that there are benefits in raising metacognitive awareness in the classroom. These research findings have led me to believe that it may also be possible to further enhance the benefits of metacognitive training by including all aspects of the expert learner. This is because these expert learners are very aware of their metacognitive actions in a very broad sense, which incorporate not only cognitive factors but also motivational and resource management ones. They particularly reflect on these *throughout* the learning process. This description of the expert learner (Ertmer & Newby, 1996) is not domain specific

but relevant to learning in any domain. To raise awareness of this process however, it is clear from the literature reviewed that students do need to understand how it can be used within a specific learning area.

Researchers, concerned with developing children's number sense have called for teachers to alter the way that they organise the classroom, and their opinions concerning what students need to be engaging in do include areas identified in the *Expert Learning Model*. It is therefore pertinent to investigate if this understanding of the expert learner can be incorporated into normal primary mathematics number learning by the use of the reflective prompt and reflective discussion, and whether it may be a useful tool in developing number sense.



## **CHAPTER 3: METHODOLOGY**

This chapter describes the design characteristics of the research study. I begin by describing the design of the study including my choice of paradigm, which I then justify. Next the sample chosen is described and justified. My data collection procedure is then outlined, and particularly important in these sections is the description of the data collection instruments used. This includes myself as a participant observer where I describe my background at this point and my potential biases. Within the description of the data collection I also describe the data analysis methods from taking a predominantly ethnographic approach. Lastly I describe the limitations in the methodology.

### **3.1 Research Design**

As outlined earlier, the study explored Year 6 children using an expert learning process designed to promote expert learning when tackling number topics in the primary school. For my research I wanted to adopt a different methodology to Herrington's research (1992). Using Herrington's approach as a springboard, I planned a predominantly qualitative inductive study to create rich data from the classroom, observing the effects of the reflective prompt rather than Herrington's more quantitative approach. I included some quantitative data collection in order to support the qualitative data but this was not the main approach.

As this was an exploratory study, it was decided that a case study approach would be suitable. A case study "typically involves an observation of an individual unit" (Burns, 1994, p. 312). It is essential that it is "a bounded system" (Burns, 1994, p. 313) which, in this case, was one class in one school. It was important to spend as much time in the field as possible so two terms were decided upon as this was the maximum time that I had available and felt that effects would have emerged by this stage. It was an important aim of the research, to study closely the effects of the exploration, in one particular school. By taking this approach, intensive data was collected. I aimed to explore the effects on one setting which may inform interested

parties such as teachers about one setting or may be used to evaluate whether this study concerning one situation may be utilized as a focus for future research with a higher level of external validity. In order to gather the data, the case study has been described as an observational case study (Burns, 1994). It is suggested that participant observation is the usual technique and this was the approach that was followed.

This research study used a design, which did not fit completely into being described as either a qualitative or a quantitative design; instead it was a mixed methods design (Wiesma & Jurs, 2005). It included both qualitative and quantitative data collection methods, although it was predominantly qualitative.

This qualitative data was considered within an interpretive paradigm (Cohen & Manion, 1985). Using the ideas and thoughts of Ertmer and Newby (1996), the study was predominantly theory building (Burns, 1994). Cohen and Manion (1985) consider that interpretive research will do just that, and they explained that the research should begin “with the individual and set out to understand his interpretations of the world around him” (1985, p. 40). This research study accepted Strauss’s premise that the real world is complex and it is “necessary to do detailed, intensive, microscopic examination of the data in order to bring the amazing complexity of what lies in behind and beyond the data” (1987, p. 10). The research took place in a Perth metropolitan primary school, working with Year 6 students. It was imperative that the research approach acknowledged that this study was taking place in a real, not a clinical environment, and that it tried to understand the subjective world of human experience. The research endeavoured to understand behaviour through efforts made “to get inside the person and to understand from within” (Cohen & Manion, 1985, p. 39). If social reality is “the product of meaningful social interaction as perceived from the perspectives of those involved and noted from the perspectives of the observer” (Burns, 1994, p. 238), then this will affect the data collection techniques and the methods that will best suit this are predominately qualitative methods.

Within the case study design an ethnographic approach was used in order to collect the qualitative data. Burns asserts that this “less rigorous approach has gained credibility in educational research because it has become increasingly evident that over-concern with quantitative data may miss significantly important links and

relationships within an educative process” (1994, p. 247). In the initial phase I tried to make broad descriptions, as I wanted to be open to all the effects. Then as time went on “progressive focusing” (Burns, 1994, p. 248) took place, as I began to identify themes and wanted to verify these. In order to categorise the data I decided to use techniques outlined in grounded theory. This theory began when Glaser and Strauss worked to create a system to analyse qualitative data, which allowed theory to emerge from the field (Angus & Gray, 2000). The validity of this method could be questioned but Angus and Gray assert that “the theory does not exist in an objective sense but is constructed subjectively by the researcher” (p. 71). In order to work out how to analyse the data they felt that it was important to acknowledge that:

Initially Glaser and Strauss were very prescriptive about how the method was to be applied; this high level of prescription suited some researchers but was criticised by others. In recent years Glaser and Strauss have tended to regard grounded theory as a methodological approach which can be modified; to suit the nature of the topic being investigated. ( p. 68)

With this in mind I referred to Patton (1990) who held the same view that there needs to be flexibility when analysing qualitative data. The suggestions however that were given by Patton (1990) were very useful, particularly to someone with little experience in this type of analysis.

Patton also believes that “in the course of the gathering of the data, ideas about the possible analysis will occur” (1990, p. 378). So as I was proceeding, effects were clearly emerging and I used the final interviews to verify these from the participant’s perspective. Overall Patton’s work (1990), due to its clarity and pragmatic approach to conducting data in a field setting, was extremely useful in order to guide my analysis of the reflective prompts, interviews, field observations, children’s work and teacher-completed diary.

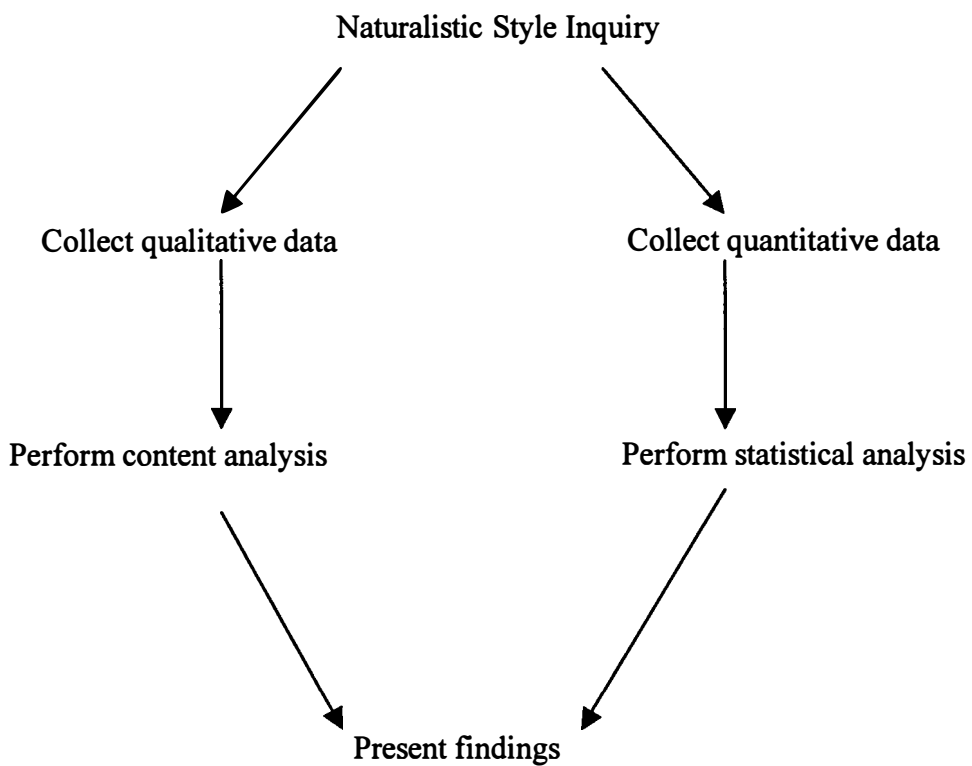
Although qualitative methods were the predominant data gathering technique, I had decided to use a mixed paradigm. There are two major reasons for this decision. Firstly I have incorporated a quantitative measure of number sense performance to increase internal validity and provide an overview to support the qualitative findings. The issue of validity is a very important one, as techniques such as random sampling are not employed. A technique selected to increase the level of internal validity of this research study is triangulation, where multiple sorts of

different data collection, such as interviewing, diaries, written evidence and participant observation supported the findings (Burns, 1994). Brown and Palincsar's (1982; 1987; 1989) successful research, which has transformed the teaching of reading in many of today's classrooms, used this method of combining qualitative and quantitative methodologies. Cohen and Manion (1985) have offered examples of quantitative data collection used effectively in a case study setting. A number of researchers (Hughes, 1990; Laydor, 1993; Verma, 2003; Johnson & Christensen, 2004; and Cresswell, 1994) expressed the view that there is value in using quantitative methods to support qualitative data. Therefore within the case study design, the class were tested for number sense ability at the beginning and end of the study.

Secondly I believe that despite concerns, that "one cannot be testing predetermined hypothesis and still remain open to whatever emerges from open-ended, phenomenological observation" (Patton, 1990, p. 194), I was keen to follow Patton who asserts that it is possible to "research predetermined questions and test hypothesis about certain aspects of a program while being quite open and naturalistic in pursuing other aspects of a program" (p. 194). In the second research question, the predetermined question is related to my perspective and my view of an effective number classroom; that is one in which number sense should develop.

Therefore as the study progressed I was open to all effects of the research study, but at the same time I wanted to consider number sense performance. For this reason I included a quantitative number sense test from McIntosh et al. (1997). This data collection stood apart from the qualitative data collection. The number sense test was administered in the initial phase and the results formed pre-test data. Excel computer software was used to hold and analyse the data. In the final phase of the study the same test was re-administered. The analysis focused on the change in the class scores. If this test, which is a "one group: pre-test – post-test design" (Johnson & Christensen, 2004, p. 276) had been the only source of data collection it would be "ineffective because of the lack of some type of comparison", but by incorporating this limited experimental design within the qualitative data collection it "helps to improve the quality of the research because the different research methods has different strengths and weakness" (Johnson & Christensen 2004, p. 50). By analysing the test data it was possible to support the more in-depth findings of the qualitative

data (Laydor, 1993; Hughes, 1990). The diagram in Figure 3 was adapted from a diagram by Patton (1990) which supported using a range of methods to fulfil the needs of the research (p. 195). The diagram explains how I predominantly engaged in a naturalistic inquiry, collected qualitative data and performed content analysis. Concurrently to strengthen the validity of the qualitative data, I also undertook quantitative data collection with an experimental design and performed statistical analysis on the quantitative data. Taking these two paths enabled me to answer the research questions more effectively than if I had only collected one type of data.



**Figure 3.** Inquiry process of the study

### 3.2 Sample

In my study I was interested in studying one class in one school so that within the scope of the study detailed, rich data could be collected. I was also interested in selecting a primary school, as this was the age range I was interested in. For these reasons the research setting that I selected for the case study was a single class at a Catholic school in the Perth Metropolitan area. The school was approached and

asked if they would be willing to voluntarily take part in this study and the school principal was very supportive. The letters that were sent to the Principal and teacher are included in Appendix F. He felt that interactions between the university and school could bring benefits to all parties. The school had approximately 900 students and it incorporated a half-day kindergarten program taking the children right through to Year 7. The school included children from a variety of socio-economic areas but the children were from predominately middle socio-economic backgrounds. It included a strong pastoral emphasis and the children were generally caring, polite and courteous. The buildings were single storey brick and the rooms were approximately ten by seven metres. Numbers of children in the classes were relatively large, having approximately thirty students in each. A Year 6 class was asked if they would be willing to be studied. It was one of a three-stream year selected after discussion with all three teachers. Miss Smith's (pseudonym for the teacher) class was chosen. This class was selected due to the teacher not having any other conflicting commitments and feeling comfortable with participating with the researcher in the classroom. Children were sent letters home to ask if they would like to participate in the study and all 32 of the children agreed to be involved. The information and consent letter is included in Appendix F.

### **3.3 Instruments**

In the following section I describe the instruments that were used in order to collect the data. The instruments are both qualitative and quantitative to provide the most effective data collection possible, in order to answer the research questions.

#### **3.3.1 The Reflective Prompt**

The reflective prompt (Appendix C) was at the centre of this study. I broadened the questions the children were asking themselves from Herrington's cognitive-metacognitive focus (1992) in his self-questioning sheet to include motivational and resource management issues which Ertmer and Newby (1996) felt were essential for expert learning. They had provided an example of self-questions that adult learners may ask themselves as they proceed through a learning process and I used these to make adaptations suitable for a younger audience. When adapting

the questions I tried to make the language more simple; suitable for the age range 6-12 years old. I felt that it was important to maintain self-questions about cognitive, motivational and environmental questions due to the reliable research evidence that cognition/metacognition (Herrington, 1992; Meichenbaum, 1985; Garafalo & Lester, 1985; Naglieri & Johnson 2000) motivation, (McKeachie, Pintrich, Lin & Smith, 1986; Silver, 1987; McLeod, 1990; Cobb, 1990; Dart et al., 2000) and resource management issues (Dunn, Krimsky, Murray, & Quinn 1986; Burke & Burke-Samide, 2004). I did try to pick questions that would be of use in the physical setting of the classroom so I omitted questions such as “when and where do I study best?” as this question lends itself more to an independent study environment. The prompt also included a section for planning, monitoring and evaluating, because Ertmer and Newby (1996) assert that expert learning undertakes this self-regulatory process. The questions have remained very general, as they needed to be suitable for any number lesson. Obviously when the child asked, “Do I understand what I’m doing?” the student would relate it to whatever number concept was being taught at the time.

It was designed so that only one sheet needed to be used each week, making it practical, cost effective, with minimum photocopying costs, and not too cumbersome. At the beginning the students had to write what the goal of the lesson was. The middle section consisted of a series of yes/no questions which reminded the children to consider these aspects.

Bruer (1994) asserts that is important that any strategy instruction should be linked to the context in which it is going to be used and so the reflective prompt was fully incorporated into the normal mathematics lessons. The participating children individually completed the sheets at the beginning, and middle of the lesson. These answers, along with the notes completed at the bottom of the reflective prompt, were useful written evidence in order to assess any changes. The children then kept their weekly sheets in a folder, which could be consulted whenever they wished.

### **3.3.2 Semi-Structured Interviews**

Semi-structured interviews were an important tool which provided meaningful insights. They allowed the students and teacher in the study to express their points of view. This form of interviewing is recommended as “this permits a greater flexibility than the close ended type and permits a more valid response for the

informant's perception of reality" (Burns, 1994, p. 279). Bell (1987) recommends the approach of semi-structured interviewing providing "freedom to allow the respondent to talk about what is of central significance to him or her ... but some loose structure to ensure that all topics which are considered are crucial to the study are covered" (p. 94).

I conducted an initial interview with the teacher involved in the study. The teacher was not a focus of the study but it was important that I was aware of the context that the research was taking place in and the teacher who is a very important part of this. The answers to the questions were part of the picture that I was able to build up concerning the setting of the research.

The initial interviews of the participating children were very useful as they allowed me to get to know the students and get a feel for the context that I was involved in. Examples of these are available in Appendix H. It was important to ask the same questions to each child at this stage, as it allowed me to build up a picture through hearing the different answers to the same questions. It was beneficial to have designed a semi-structured interview as some of the children were quite shy and I do not think in an unstructured interview they would have opened up freely at this stage. As this was an inductive research study I did not have any specific lines of inquiry that I was going to pursue in the qualitative data collection, as I was observing whatever effects might arise. Instead the interview questions were "guided by broad research interests" (Burns, 1994, p. 248). The questions referred to a number of areas such as, beliefs about learning mathematics, did they enjoy learning mathematics, and were they involved in group mathematical activities. I also interviewed all the children in the class so that all perspectives were considered and this first standard interview protocol is available as Appendix G. Following the interviews I transcribed the relevant points that students made.

The final interviews also had a more specific purpose and examples of these are available in Appendix J. They were designed mainly so that I was able to verify with the students if they felt that the implementation of the reflective prompt had affected them in the ways that I thought it had. I also wanted to ask the children some of the questions that I had asked them initially to identify if there had been any changes in their thinking about how they learnt. By interviewing all the students, I was able to make sure that I gained the perspectives of the whole class and this was



extremely useful in creating the general themes related to the effects of the study. The children were always keen to please and needed to be reassured that they could say what they truly felt. Some children would only give short answers and seemed worried that they would say the “wrong” thing. I also specifically avoided using any formal language so that they would not be intimidated. These interviews involved specific questions, but as time went on, some children become quite animated so I also used these initial questions as a springboard to ask further questions or “probes” (Maykut & Morehouse, 1994). This method clearly added “richness to the data”. It is important to note that the students in the study were aged ten and eleven. Certainly while the interview was an important data collection tool it was useful to have other data to support and act as triangulation. Although the students were old enough to express their point of view clearly and these views definitely had credibility, they still have to be considered in the context of being children’s perspectives.

### **3.3.3 Participant Observer**

As a participant observer I was an important tool involved in collecting data. Patton (1990) insists that, “any credible research strategy requires that the investigator adopt a stance of neutrality with regard to the phenomenon under study” (p. 55). It is also important that I approached the setting with “empathy” which communicates interest in and caring about people” ( p. 58). This was the stance that I took even though the research setting was quite a contrast to my educational background.

I was trained with an emphasis on discovery methods in the United Kingdom and the culture in my first teaching post supported this approach. Politically, at this time, there was discontent with this approach, particularly the small amount of time that pupils had teacher contact. My second teaching post was at an international school, which initiated a process of staff development of critically evaluating how teachers should teach most effectively. Working in an international environment had great benefit as teachers from many different cultures such as English, Canadian, Australian, New Zealand and American, came together to share their views on good practice. The consensus in this international school was to maintain a learner centred approach to teaching and encourage differentiated classrooms; with some accommodation for the realistic task of dealing with large numbers of children.

Generally the classes were taught a mathematics lesson at the same time in the morning. During my masters course work here in Australia and involvement in part time mathematics education lecturing, I reflected on all my personal experience of ten years in the primary classroom. I now believe a radical constructive approach to learning to best describe how I believe children learn most effectively and this was outlined in greater detail in Chapter 2.

My contrasting approach to teaching compared with the teacher's approach in the field, meant that it was important that I considered this very different setting, with its own unique culture and history, with a neutral stance when collecting data (Patton, 1994).

This collection of data focused on the participating children in the class and I recorded the discussions, actions and written work of the students in their number classes. As well as observing the number activities, I observed the final whole-class discussion which asked the students to reflect back on the learning process. They were asked such questions as, what they learnt, and what they still did not understand (Appendix E). Excerpts from the classroom note-taking are in Appendix L.

At the beginning of the study I wanted to record data that allowed for a "wide range of possible ideas and lines of inquiry" (Burns, 1994, p. 257). Gradually I became aware of themes and started to focus on these in my data collection. Lastly the final weeks concentrated on verification of these themes. In this stage I especially focused on how students responded to the reflective prompt during the study. I managed to focus on each child at least once. In a classroom, which was very orderly, it was straightforward to observe the general behaviours of the children. These observations were limited in some respects because the children were mostly completing mathematical tasks individually and silently, so it was difficult to record dialogue. The observations were also hampered by the physical setting, which had the children sitting in rows.

I also helped to teach the children as a way of becoming immersed in the program, to offer some 'pay back' to the teacher and allow for the successful implementation of it. This involved being available on a one-to-one basis, responding to written questions in their reflective prompt and taking the number class once each week. There was obviously a conflict of personal teaching styles and I felt that ethically I wanted to give the children opportunities to learn with relational

understanding (Skemp, 1976) wherever possible, but I had not asked the teacher to change her teaching style and so it was important not to ask her to do this nor undermine her position. This was a difficult tight-rope walk to follow. I took the class once a week on the understanding by the teacher that it would follow normal procedure. This meant that there was usually little teaching for understanding planned in the lesson but I would try to inject this where it was not too disruptive nor deviating too widely from the teacher's normal approach.

### **3.3.4 The Teacher-Completed Diary**

This study was focused on the learners' perspective so the teacher perspective was not one that the data collection was focused on. To have also focused on or looked from her perspective was beyond the scope of this study. For the purpose of internal validity however, I did ask for her perspective through a teacher-completed diary. She completed a diary to record her thoughts throughout the process. These reflections included perceptions of the exploratory study, and such aspects as, interesting observations of the children's progress, teaching issues, and any other effects of the study. This highly personal data allowed for a different perspective from that of the researcher to be recorded.

### **3.3.5 Written Evidence**

It was important to observe the children's mathematical understanding so, as the children completed their mathematics activities, pencil and paper evidence of this was collected at various stages of the study. This evidence showed the children's completion of the written mathematics exercises. This was useful evidence so that any changes could be identified, and it increased internal validity by adding to the sources of evidence available for analysis.

### **3.3.6 Number Sense Test**

In order to further support this endeavour I used the number sense test developed by McIntosh et al. (1997) to collect quantitative data. This instrument, which has been used in an international study, provided me with evidence which showed effects of the intervention. I decided therefore, to conduct a “one group pre-test – post-test” design. Johnson and Christensen (2004, p. 276) make the point that this design is not ideal when attempting to generalise because of the many different variables which may have effected the outcome. This is not necessarily a limitation in this study, as the data is meant to support the predominantly qualitative data collection rather than it standing alone. It is also not possible to generalise from the data as I did not select “a truly random and statistically representative sample that will permit confident generalisation for the sample to a larger population” (Patton, 1990, p. 169). Instead my aims in this case study were to achieve internal validity.

The different sections in the test ask insightful questions concerning children’s numbers sense and can be analysed effectively. The protocol for administering the test was the same that McIntosh et al. (1997) used and details of the procedure are given in Appendix A. Number sense demands a good understanding of our number system and children who do well in this test possess understanding, not just effective pencil and paper techniques. The same test was administered at both the beginning and at the end of the study. While obviously it could be argued that the validity of the test was reduced because the children have already seen it, two terms had passed making any clear recollection unlikely, and there was no analysis of the test with the class when it was first administered. The bonus of the same test being administered is that any changes in results could be compared directly.

### **3.4 Data Collection and Analysis**

As explained previously my data collection was both qualitative and quantitative. Below I have outlined the qualitative data collection procedures first, as this was the main approach. Then I have outlined the methods for the collection and analysis of the quantitative data.

#### **3.4.1 Qualitative Data Collection and Analysis**

The ethnographic approach to collecting the data meant that the collection was intertwined with the data analysis (Burns, 1994; Patton, 1990). It is therefore appropriate and helpful to discuss these in conjunction with one another.

Primarily this research focused on a case study with descriptive data gathered from classroom observation, documents such as evidence of work, the number sense test, and interviews. The data analysis needed to focus on “understanding and description” (Angus & Gray, 2000, p. 57), so therefore a predominately qualitative research approach was appropriate.

Integral to answering the first research question was the identification of the effects of the study on the Year 6 learners. In order to be meaningful this data needed to be organised in a suitable manner. Burns (1994) asserts “adequate understanding of school programs requires thorough descriptions of what happens in the classroom from the perspective of the participants” (p. 248). He divides ethnographic projects into three phases and I used this as a basis for my data collection/analysis. Below I have explained the data collection and analysis which was undertaken in each phase but it is useful initially to observe the chronology of each phase with reference to the school terms. The teacher and I decided that due to disruption of the classes at the end of term, to end the initial phase just before the last week of Term three and end the middle phase after seven weeks of Term four. The following table explains how I divided my time up in the field.

Table 1. Timetable for the Time Spent in Field

<u>Term</u>	<u>Data collection phase</u>
Last 2 Weeks of Term 2 and Weeks 1-9 of Term 3	Initial phase
Weeks 1-7 of Term 4	Middle phase
Week 8 and Week 9 of Term 4	Final phase

In the “initial phase” (Burns, 1994, p. 248) I made general observations. These were collected from observing the children in their number classes, noting down the organization of the lessons, the teachers and children’s actions, and accepted cultural beliefs of the classroom. I noted the children’s reactions to initially completing the reflective prompt and how the implementation procedure went. I interviewed the children all individually in this phase. I used questions from a structured interview schedule that can be found in Appendix G. As I did not know what path my line of enquiry was going to take I asked them a variety of questions and recorded important information that they provided through their responses. It was an excellent way of getting to know the children and therefore it was also of great benefit to the study. I wanted to appreciate what it was like for students in this setting so that I would be able to begin to understand their world and what this experience was like for them. The classroom observations continued, but after nine weeks in the class I decided that I needed to withdraw and assess what I had observed so far. It was fortunate that at this time it was also the end of Term three. While the children were on holidays it gave me a chance to reflect on what was happening and plan to start focussing on investigating if the effects of the reflective prompt were what I began to think they might be.

When Term four began again I continued the classroom observations focussing more on trying to find out if my speculative general effects were in fact happening and then spending time collecting supporting evidence. I also took copies of children’s written work that they had completed in the lessons. This phase has been described by Burns as the “second phase” (Burns, 1994, p. 248).

Before withdrawing finally from the field, I also collected the children's reflective prompts and the teacher's diary as a vital source of documentary evidence. My last piece of qualitative data collection before withdrawing finally was to interview each child again. These interviews were short but focused and were used to verify my emerging ideas. In many ways this could be described as "third phase" (Burns, 1994, p. 248,). I had built up a very close rapport with nearly all the students. It was very important in the interviews not to break that. They were always keen to please and I did not want them to feel that they needed to impress me. I wanted to verify with the children that the impressions that I had about the effects of the study were true. I prepared a list of questions but deviated from these where I was interested in finding out more from the children. The children varied greatly in their answers. Some of the children were quite shy and their answers were very brief despite me trying to probe deeper. Other children were more revealing and keener to share their views. In this third phase the whole emphasis of the interviews was to verify the identified themes.

Once I left the classroom at the end of Term four, I embarked on the final data analysis. I had taken note that one way of proceeding with this was described by Burns who suggests, "coding" (Burns, 1994, p. 288). This idea was developed by Glaser and Strauss and termed 'Grounded theory' (Burns, 1994; Angus & Gray, 2003; Patton, 1990). While this case study was not following a pure grounded theory approach, I decided to use some of the techniques. After leaving the field I therefore embarked on the "content analysis" (Patton, 1990, p. 381) stage. This consisted of searching through the data and coding it in relation to different themes. The codes were then ordered according to importance to form an account of the effects (Angus & Gray, 2003). Patton (1990) describes this process:

The strategy of inductive designs is to allow the important analysis dimensions to emerge from patterns found in the cases under study without presupposing in advance what the important dimensions will be. The qualitative methodologist attempts to understand the multiple interrelationships among dimensions that emerge from the data without making prior assumptions of specifying hypotheses about the linear or correlative relationships among narrowly defined operationalised variables. (p. 44)

As I had focussed on effects on the students in the classroom, I was interested in representing this effect from the pupil's perspective, not the teacher's or

my own. To do this I tried to take indigenous concepts (Patton, 1990); that is create themes using words identified as the students own words in the interviews and observations to describe the data. While embarking on this process I observed that it would have been beneficial to probe a few students about their answers somewhat further. I felt that this further verification of a few students' responses would strengthen the validity. Guifoyle (personal communication, January 2005) recommended that it was methodologically sound to re-enter the research field to seek clarification from interviews if necessary.

Finally, satisfied that my data collection was complete, I coded the data (Appendix N) and actually pasted the data onto card. This procedure created an audit trail so as to increase accountability (Maykut & Morehouse, 1994). Maykut and Morehouse also found this "hands on approach helpful for learning to do data analysis and for being able to visually pore over a large amount of data simultaneously" (1994, p. 148). It certainly was of great benefit as it allowed for the different data collection methods to be considered holistically and this triangulation of different types of data confirmed my identification of important themes. These emerging themes reflected the effects from the viewpoint of the participants – that is, the Year 6 students. Although I had started to identify themes before I left the field, I made sure that I looked very critically at the data in order to ensure its reliability.

To further illuminate the findings, I took note of Burns, who asserts that "adequate understanding of school programs requires thorough descriptions of what happens in the classroom from the perspective of the participants" (1994, p. 248). I agreed with this and felt it was necessary to explain the chronology of the study and give a full description of what it was like to be in the program. Maykut and Morehouse (1994) try to encourage researchers to offer this type of description so that the resulting qualitative research is as open and trustworthy as possible. In order to do this I presented a description of the unfolding of the study. I began writing this at the beginning of the study to take advantage of the events being fresh in my mind and it also helped to clarify my thoughts as I began recording the effects. I continued with the chronological account throughout the study, alongside the writing of field notes. This aimed to support the "ethnographic approach" (Burns, 1994, p. 248) of this research study which recognises that it is important to "see social life with the general context of a culture ... the ethnographer must be aware of the classroom



setting with a wider context: the surrounding vicinity, the milieu of the values and beliefs, the larger social environment” (Burns, 1994, p. 250).

### **3.4.2 Quantitative Data Collection and Analysis**

For the second research question, I adopted a quantitative approach. In order to support internal validity and provide as meaningful a picture as possible, I used the number sense test to answer the second research question. It did not provide rich descriptive data but instead supplied quantitative results to support the qualitative data. The quantitative number sense test, in many ways, stood apart from the qualitative data collection. The number sense test was administered to the whole class in the initial phase, as in Appendix A, and the results formed pre-test data. Excel computer software was used to hold and analyse the data. In the final phase of the study the test was re-administered using the same protocol. The analysis focused on the change in the class scores. By analysing the data in this way it was possible to suggest impacts of the study and it was combined with the more in-depth findings of the qualitative data (Laydor, 1993; Hughes, 1990).

### **3.4.3 Analysis of Research questions Combined**

I had designed the second research question to support the first question, so it was necessary to consider the findings from the two research questions in combination. In order to achieve this I assembled a research network diagram, (Johnson & Christensen, 2004) as described in Chapter 5, to describe the total findings of the research study. In this way the research questions could be considered as a whole.

## **3.5 Limitations in Methodology**

In this case study the central aim was to describe what happens in one setting and it has been designed this way for the reasons explained earlier. It is an obvious limitation of the study that it is difficult to generalise when focusing on a small unit, without such techniques as random sampling (Burns, 1994) and therefore it lacks

external validity. The study has been designed however, so that it should have internal validity and the information described should hold value for the reader. Burns (1994) asserts that:

many case study proponents would argue that any generalisations should be reader ones. Thus the reader decides the extent to which the researcher's case is similar to and likely to be instructive to theirs.  
(p. 327)

In the future the findings of this small research study could be replicated, allocating greater resources and time, using a method with higher external validity, in order to find if generalisation is possible.

Another limitation is the possibility of subjective bias (Burns 1994). It can be difficult for the researcher to be wholly objective when collecting the data. It was also a lone research topic. It would obviously have been advantageous to have had another researcher who could have looked at the data independently as recommended by Patton (1990). It was anticipated that triangulation techniques were used to overcome this and combat any subjectivity.

Lastly the Hawthorne effect must be acknowledged. As this is a study where the students are fully informed of the intentions of the study it is likely that this effect may occur. In some ways however, the Hawthorne effect is part of the study, as focusing on the children's learning is important in motivating the children. Motivation is an important aspect of the expert learner and the study emphasises the importance of showing the children that their learning is important. A regular teacher in another setting could replace this motivation provided by the researcher. The teacher in this study did not change her teaching style and continued teaching with a similar pace and effort all the way through. This limited the Hawthorne effect from the teaching perspective and the general classroom environment under which the study took place under.

## **CHAPTER 4: FINDINGS**

The findings encompassed broad descriptions in keeping with the choice of research study, which was a case study. In contrast to quantitative reports, qualitative reports “will vary depending on the type of qualitative research conducted and the result of the data analysis” (Johnson & Christensen, 2004, p. 540), and as I have chosen this case study to embrace a qualitative style, despite including some quantitative data collection, this section does not follow a traditional quantitative results format.

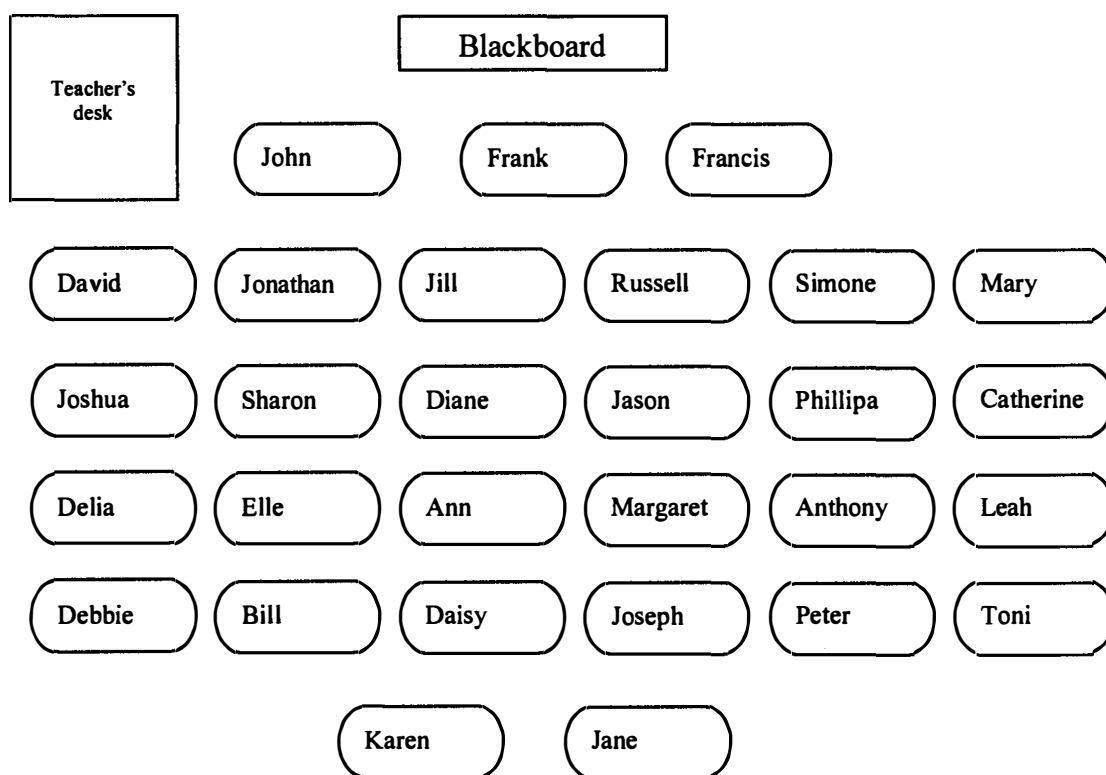
### **4.1 Description of Context and Participants**

I have provided a description of the context and implementation so that the effects of the reflective prompt on Year 6 students were more transparent. The intention is that a clear description of what it was like to be a student in this case study be made available. It was also important for the implementation process to be described in case this research is replicated in the future.

#### **4.1.1 Context**

The school buildings were single storey brick, and the rooms were approximately ten metres by seven metres. Numbers of children in the classes were relatively large, having approximately thirty students in each. The classroom layout, shown in Figure 4, had individual desks which stored the children’s work. They were organised in rows facing the blackboard. At the front there was a white board, blackboard and an overhead projector. The teacher’s desk was to the side. There were some pictures on the wall as well as notices. Overall the classes seemed very crowded and cramped. The colour scheme consisted of grey and burgundy, which was not very enticing. The desks had to be lifted up to get out their books and then anything that was on their desks would fall off. The class had 33 students in it. They were generally well behaved and courteous. One child in the class has severe special

needs. It was decided that she would not take part in the program. She had her own individual program and it was decided that this study would hold no educational value to her whatsoever and be inappropriate. The classroom chosen was a standard room within the school and it had desks arranged in lines. The behavioural system that was in place was a warning system with various levels of punishment. The levels ranged from the student's name on the board for one misdemeanour, a cross by the name after two misdemeanours, and when two crosses had been given students would have a note written in their homework book.



**Figure 4.** Classroom layout with children's names as pseudonyms

The teacher, Miss Smith, was new to teaching Year 6 at this school although she had previously taught Year 5 at the school. She seemed confident, although a little defensive and wary at times. When I asked her about her background she said,

*My background was in South Africa. I taught in government schools for four years. Catholic school for nine years. When I came to Australia I taught in a Government school, then I went to the country. Then I did relief in Catholic schools and then here.*

I then asked her if she enjoyed teaching mathematics, she said:

*Most of the time. If I have a good group of children that are good it's challenging.*

She described her teaching in terms of having a syllabus and delivering it.

*We do have a syllabus that we follow. We can use which textbook we want to use in the year level. It is based on the government one [seemed to have no awareness that this is not being followed now in government schools]. I decide whether to teach this depending on whether it is in the syllabus. I check this.*

She was aware that weaker children needed to have support and in her interview she did say that weaker children were given remedial work. In practice, in my time with the class, I never saw weaker children being given reinforcement activities and I felt that the teacher's beliefs were in some ways conflicting with the education system operating in Western Australia. This is a clear example of the conflict of emphasis between relational understanding and instrumental understanding as described by Skemp (1976).

#### **4.1.2 Mathematics Curriculum at the School**

The Western Australian Education Department released a *Curriculum Framework* in 1998 which all government and non-government schools were expected to follow. It placed no stipulation on how these outcomes should be achieved. The Progress Maps produced by the Curriculum Council (2005) described how the subject is to be understood:

In Mathematics students learn to use ideas about number, space and chance and mathematical ways of representing patterns and

relationships, to describe, interpret and reason about their social and physical world. Mathematics plays a key role in the development of students' numeracy and assists learning across the curriculum. (p. 11)

Parents and students receive information in report forms, which refer to this framework. As the school had been told by the Catholic Education Office that it needed to provide parents with the information during the time of the research study, there had to be some reference to this document in the teacher's planning of mathematics education even if the teaching was not yet fully in line with teaching to the document. This pressure to report to parents with reference to the curriculum document gave me the impression that these aspects had been rushed through without careful analysis. This obligation, however, does not mean necessarily that the spirit of the document was embraced nor its all-pervading outcome 'working mathematically' followed.

The school culture seemed fairly conservative in its attitudes towards mathematics and there was not great parental knowledge of what the Curriculum Council of Western Australia perceives mathematics to be. This was complicated by the local suburbs having an unusual number of migrants, coming from many different parts of the world such as South Africa, Italy, Ireland and England. These very different backgrounds naturally meant that many of the parents came to the school with different ideas of what mathematics is, and after talking to some of the parents I assessed that there was little parental information about the aims the subject of mathematics in the *Curriculum Framework* in Western Australia.

According to Miss Smith, the curriculum was organised using the original Western Australian government syllabus. This document had clearly laid out objectives and planned activities, which teachers could organise in their mathematics classrooms. The document held a few different sections. There was a handbook that contained many ideas about the process of teaching mathematics, which would enable children to learn mathematics with understanding. This is an excerpt from the book (Curriculum Programmes Branch, 1989):

Mathematical learning involves the acquisition of processes as well as an increase in content knowledge. The processes are employed across a range of areas and are not tied to any particular aspect of content.  
(p. 4)

It also contained a file, which included the content to be covered. If only the content of the document was considered the processes would be lost. This may have happened in this school, as the delivery approach within the class was a transmissive one. Topic content was delivered at a certain level and a topic test was conducted at the end of a topic in order to assess ability. I have included one example of the topic test in Figure 5.

Term 3 Week 5 Number Test 30/6/04

33  
50

**Complete these number sentences:**

1)  $(4+5) \times 3 = 27$  ✓  
 2)  $3 \times (4+4) = 24$  ✓  
 3)  $18 + (9-7) \times 6 = 30$  X  
 4)  $(7-4) \times 5 + 4 = 27$  X  
 5)  $(5+11) \times (4-2) = 32$  ✓✓  
 6)  $7-3 \times 2 + 9 = 8$  X

**Complete these number patterns**

1) 5, ~~10~~, 20, 40, 80  
 2) 56, 51, 46, ~~41~~, 36, 31 ✓  
 3) 7, 13, 19, 25 ✓✓  
 4) 7, 17, \_\_\_\_\_, 107, 157  
 5) 9, ~~16~~, 24, 44, ~~84~~, 164

**Put in the greater than or less than signs, < or >**

1) 660 < 826  
 2) 40 < 50  
 3) 25 > 11  
 4)  $(3 \times 9) \div 3 + 4 < 15$   
 5)  $(8 \times 7) + 4 > 59$   
 6)  $(5 \times 6) + 3 + 5 < 20$

**What are the factors of the following:**

1)  $10 = 2, 5, 10, 1$  ✓✓  
 2)  $25 = 5, 1, 25$  ✓✓  
 3)  $35 = 5, 35, 1, 7$  ✓✓  
 4)  $44 = 11, 4, 1, 2, 44$  ✓✓  
 5)  $50 = 10, 5, 1, 2, 1$  ✓

**List the prime numbers from 0 to 30** 2, 3, 5, 7, 11, 13, 17, 19, 23  
 29 (4)

**On the back of this page draw the prime factor trees for:**  
 24, 32, 48, 64

Figure 5. An example of a student's topic test

This approach was further supported by the use of year group textbooks which organised activities for a single level of ability. The curriculum was delivered in such a way that a particular mathematical objective was outlined for each lesson.

The children were accustomed to completing the activity to achieve this objective. They were then assessed as to whether they had met the year group outcome (related to the Mathematics Outcomes from the Curriculum Framework), exceeded it or not achieved it. The different mathematical abilities in the class, meant that some children found these concepts quite easy whereas others found them quite challenging. It was important for me as the researcher to accept this way of working without judgement when approaching the research setting, appreciating that in the real world there are many conflicting beliefs about what mathematics is. Miss Smith believed that transmitting mathematical ideas such as algorithms and rules was the way to teach mathematics and that this delivery should all be at one level. The parents and the school were accepting of this approach. Miss Smith did give some indication that she felt that she should differentiate the work and occasionally provided extension worksheets for bright children. The school certainly had a support system for children with special needs to help alleviate their difficulties. This was organised where they were supported in order to complete the work given to the majority of the class. A special needs teacher, Mrs Baxter (a pseudonym), who came in for in-class support for two of the number lessons each week, provided extra help for them. It seemed a difficult task however and Mrs Baxter did admit that she actually preferred to withdraw the children rather than try to work in the way organised by the school.

Various mathematics topics were selected for each term. The topics for Term three were:

- Number Patterns and Number Sentences
- Equality and Inequality
- Relations between Decimals and Fractions
- Percentages in Everyday Situations

The topics for Term four were:

- Long Multiplication
- Multiplication of decimals by whole numbers
- Division with remainders



### **4.1.3 Participants' Beliefs about Learning Mathematics**

I also interviewed the children to find out about their beliefs about learning of mathematics. I asked the children how they knew they had learned something in Mathematics. David said: *I feel good if I get a good score in a test or something.*

Some of the children did refer to learning as something that involves understanding. Debbie did make the comment that she knew that she had learnt something because *I understand it*. Many of the children's comments, though, revealed a conception that learning was about getting the answers right. Catherine felt that the teacher knew that they had learnt something, *when she tests us*.

The mixture of responses reflects the mixed messages that children were receiving, concerning the aims of education. I felt that the pupils adopted a superficial approach to learning rather than to explore and truly understand the concepts before them. There were definite references to understanding within the classroom textbooks, which made references to such suggestions of activities as 'investigate', as these books are being written to help teachers implement the Curriculum Framework with its emphasis on 'Working Mathematically'. In this setting children were told to skip sections that may have aided investigation and understanding. From my perspective it has to be realised that idealistic aims of constructivist education are not always the ones that society really wants and the teacher and school are under pressure to fulfil the more traditional notions of success – that is, for children to be able to get right answers, follow rules and so on.

## **4.2 Description of the Implementation of the Program**

The study was to be exploratory. It had quite definite aims but the individual nature of the class was considered and the procedures were influenced by the distinctive nature of the research situation.

Within the case study approach, I decided to use a variety of research methods over a period of two school terms. The data collection was divided up in order to capture the longitudinal, be it fairly short, nature of the study. It consisted of the initial phase, the middle phase, and the final phase. I entered the school in the last two weeks of Term 2. In these weeks I administered the number sense test which is

in Appendix A and interviewed the children using the interview schedule which is in Appendix G. I also explained the program to the children. To do this I read them the story of Emile and Monica from Ertmer and Newby (1996):

It is easy to see that the difference between Emile and Monica is not due so much to the amount of content knowledge each possesses ... as to the approach each takes for learning new information. (p. 3)

I explained to the students how experts generally do certain specific things and that hopefully soon they, the students in the class, would be thinking like experts in their number classes.

At the very beginning of Term 3 we started the implementation of the reflective prompt. This Term and most of Term 4 covered the middle phase. The children continued to fill in the reflective prompt as I fulfilled the requirements of the final phase. The program finished the week before the end of Term 4 as teaching had been terminated by that stage.

It was constructive to describe this implementation in order to understand how the study progressed and appreciate that some of the effects occurred at different times of the study. Although the teacher was not the focus of the study it was important that her role be described. It also added trustworthiness to the study, allowing the implementation to be clear so that others can “judge the quality of the resulting product” (Burns, 1994, p. 463). Researchers wanting to replicate the study could understand the process that I undertook (Burns, 1994). This record was written while I was in the field as part of my observations and was an important record of the study to supplement the field notes. From my notes I wrote how this expert learning process was implemented in the Year 6 classroom:

*In the initial observation, I introduced myself to the class and spent a short time getting to know the children. Interviewing them was an ideal way of meeting each child individually in order to gain entry into the school environment and I felt that it was important that I was perceived as a trusted helpful person who supported their classroom practices. I set about making some general observations. The number sense test was administered to the participating students in the class in the appropriate manner in order to have some gauge of mathematical ability. I interviewed the teacher to find out what her approaches to teaching mathematics were and the introduction of the teacher-completed diary was initiated. The participating students were also interviewed individually to find out how they perceived*

*their mathematics learning. This interviewing activity also allowed me to get to know the participants a little better and allowed to gain the trust, which was extremely important.*

*The next phase was the implementation phase. My aims were to use a constructivist approach so I needed to facilitate the teacher's learning about the proposed study, so that she would be able to act as the facilitator and guide to the children's learning. An initial professional development session allowed me to discuss with the teacher about the project. It was useful that she was able to sit in on the sessions with the children so that this reinforced her understanding. In the sessions with the children, I read to them the description of the expert learner and explained that expert learners don't just wave magic wands they do certain things. I explained that many of these processes were included in their expert learning sheet and that if they completed this sheet and tried to do the things on it they would be working like expert learners. I also made available the original article by Ertmer and Newby to the teacher so that she could reflect on it. The next session outlined in detail the proposed introduction of the reflective prompt, which would include writing and reflective discourse. The teacher was able to explain how her classes were organised and she described she normally had number classes of about one hour and these were three times per week. I saw that this would easily allow for the implementation of the expert learning process with very little adaptation. The teacher was able to highlight some concerns that she had and sort out practicalities such as the mathematical activities planned for the term, and the needs of the children. The teacher and researcher agreed how the class would be structured, using a framework of some planning time, then activity and reflecting on this action, and finally a reflective session as a starting point.*

I did not ask her to change her teaching style in any way. I had felt that a normal, real classroom without any changes in relation to the teaching environment was a necessary starting point in researching the expert learning process. In my case record I then wrote:

*Once the teacher felt satisfied with the plans, the expert learning process was introduced into the classroom. For the data collection to be worthwhile and ethical it was decided that at least 50 percent of the children in the selected class would need to agree to be participants. If less than 50 percent of parents approved of their children's participation then the study had the potential to be disruptive to the non-participants. It was extremely promising that of the 32 children in the class who were invited to be include in the program all of them agreed to take part in the study.*

*Initially I worked with the children in the classroom in order to establish the program. All the important aspects of the program that were needed to be put into operation were implemented. At the end of each mathematics class, I asked the children to reflect back on some aspect of their learning. I asked them from a list of questions ... The pupils were not used to having a plenary session of any kind.*

Further in my notes I wrote:

*On Thursdays Mrs Baxter came into support the children who had been identified as having special needs. This was very interesting as this was a small window where some of the pupils' individual needs were listened to and she was able to make adaptations to suit their learning. In one episode she identified that the children in her group still did not understand long multiplication and she explained that she would try to find time to further support the children.*

In this phase I continued to play a central role in the procedural matters of the expert learning process. In my case record I noted:

*I continued to step in with the guidelines concerning the following of the reflective prompt. The children got into an effective routine of every day listening about the day's lesson, then before commencing, filling in their reflective prompt. Half way through, myself or one of the children, would ring some small cymbals to inform children that they needed to fill in the middle section of their reflective prompt and then at the end I would stand up and ask them some reflective questions. I adapted my initial final reflective questions and instead tried to tie it in with what they had been actually doing and this seemed more successful. On one day for instance the children had been solving problems relating to percentages. They were given 0.3 and asked to express this as a percentage. We discussed this and I asked them what cognitive strategies they used to do this. Bill said "I count how many digits there are and from that make it into a percentage". I modelled my own thought process and explained that when I see that I say to myself.  $\frac{3}{10}$  is  $\frac{30}{100} = 30\%$ .*

*Discussion in the class remained limited; instead the children had the practice of talking to the person next to them if they needed clarification on something.*

*The emphasis was on learning rules such as:*

*“What you do to the numerator you do to the denominator.”*

*At the beginning of lessons Miss Smith often spent a large amount of time at the board going through how to solve algorithms while the children were expected to watch, listen and absorb the procedure. There was little opportunity for discussion. Due to the stigma, which some children felt if they voiced any inadequacies. They used various strategies to avoid sharing their opinions.*

*In order to try and encourage the teacher to become involved in the process, I did ask her for some feedback on the prompts. She did this, reading the folders over the weekend. She gave me some positive written feedback on her thoughts on the prompt but she did not change her teaching style.*

*At the beginning of Term 4 a few children started to become unmotivated when filling in the reflective prompt. Four boys in particular who were very successful in this number classroom and did not want to change anything about it would often try not to fill it in, although whenever I noticed this and mentioned it to them they would then complete it. They seemed to give the impression to me that they thought that it wasn't cool and had made the decision in their small group not to show enthusiasm for it. This attitude continued and was made worse by them becoming tired at the end of the final term.*

*On the last day I felt that it was important to withdraw very formally from the field. I felt that I was satisfied with the amount of data that I had collected and that I had enough to be able for me to answer the research questions. I gave each child a certificate to commemorate them being involved in the project and the teacher a gift. I felt that it was important to acknowledge the good will of the teacher and hard work of the children. For the teacher to be observed for two school terms and to be put under scrutiny can be stressful, so I wanted to leave the field having made it known to the teacher that I appreciated her allowing me into her classroom for this time. Hopefully this also supported the project ethically as it would have contributed to the experience being a positive one for the students and teacher. The children overall seemed to have really enjoyed the experience. Leah even saying hopefully, “ Will you be with us next year?”*

#### **4.3 Research Question 1**

***What were the effects on Year 6 students of using an expert learning process designed to promote number sense?***

After analysing the data I have categorised the effects on the Year 6 students involved in the study while completing the expert learning process. It is pertinent to mention here the themes that I have presented are my own “perspective on the program based on ... analysis and interpretation of the data” (Patton, 1990, p.483). Below I have identified and discussed some of the general themes that have emerged. Throughout I have tried to provide excerpts from the data both to illustrate points made by myself, and to describe the effects themselves (Patton, 1990; Burns, 1994). I have also tried to convey how apparent the themes were. In order to do this I have described these themes in terms of being strong or weak, as recommended by Patton (1990). It does not mean that when I described a theme as weak that it questions the validity of the effect; instead it is intended to signal that it was not a major effect. In all cases I have also tried to offer examples of exceptions to these general effects so that it is possible to have the most realistic view possible as to the effects of the study.

#### **4.3.1 Students Reflected throughout Number Lessons**

A very strong theme is that the students were able to use the reflective prompt in a ‘normal’ number lesson, reflecting on their learning. The selected class was not special in any way and actually is an example of a class working in a very traditional way. Despite the aims of the prompt being to develop learning from a constructivist perspective it was able to operate in a transmissive classroom culture. The teacher identified and wrote in her feedback that:

- [Children had] *positive (yes) responses often.*
- [Reflective prompt] *helps students to think about what they are doing or about to do.*
- *Most students realise that they need to persevere.*
- [Children] *think about having own equipment and realising that they need to have own equipment.*
- [Children] *think about what they are good at e.g. tables, reading, etc.*

The children were presented with folders and the children were all able to put their sheets in independently and complete them. Initially it took a little while for the routine to be established until the sheets did not disrupt the lesson; but very quickly the children needed no instruction whatsoever, and when Miss Smith had introduced

the lesson they were able to get out their folders and fill it in. Midway through when the cymbals would sound, the children would get their sheets out and fill them in again. I note in my classroom observations, that:

*Children filling in the reflective prompt really well today with minimum disruption.*

In this way the students were being prompted to reflect on their learning at the beginning or planning stage of the lesson, and midway through the lesson that allowed for monitoring of their learning process. It was simple to use and the language was clear; ten and eleven year-olds could easily use the instructions. There was very little laborious writing for the students and they only had to write when they felt that they wanted to. Toni continued to explain:

*We had sheets to fill in which were called reflective prompts. We had to fill in they had questions like Do you have everything you need? Is this way of working working? And we just had to fill this in. It had everything explained in it. We had to write down the first part we wrote down what our goal was. Then after 15, 20 minutes we then had to write what you have learnt new and you would have to write down.*

Diane identified the steps to be taken:

*Firstly we took out our folder. You write the date and what your name was. I got write down what I had been learning. The steps was easy.*

Through completing the prompt they were able to show any one interested how they were performing with reference to an expert learning focus and they were prompted to think expert learning questions at the beginning and middle of every number lesson. As it was so simple to fill in, the procedure was able to continue for the entire duration of the study.

Margaret also discussed in her interview how she found the completion of the reflective prompt.

*It was easy to fill in. You had to read the questions and think about what you were doing. Writing what you thought about it. The folders were good, it wasn't hard to open or anything. We filled it in twice, just before we started and half way through it would tell us what we were doing. It would have different questions to make sure that you*

*have everything you needed to do your maths. It was pretty straightforward and easy to fill in.*

In the implementation phase of the study, I observed and noted the use of the reflective prompt by Elle:

*The lesson was on rule of order. Elle was working through on number sentences such as 3 take away (2 divided 1) plus 6 equals ... She was working quickly and confidently. As she understands it she is a confident learner who is confidently filling the sheet in, happy to tick yes.*

In order to further illustrate the ease with which the reflective prompt was used in number lessons for the two terms, I have included examples of the students' completion of the reflective prompt in Appendix M. As the reflective prompt was so central to the study I felt that it was crucial to observe an example of its completion, at this point noting how the different sections have been completed. This example is taken from Ann. She found the work set for her in the class very easy. She achieved a score of 28 from a possible 35 in the number sense test. Regularly she would record that she did not have to concentrate and that she understood the work easily. Analysing her reflective prompt it is possible to identify that it was filled in correctly and reflected accurately her learning experiences in the class. The excerpt in Figure 6 shows that she has identified goals, realised that her 'tables' knowledge will help her and clearly understands how to do 'long multiplication'. To further help understand how she has filled it in correctly; I have included evidence of the paper and pencil work that accompanied the reflective prompt entry.



Thursday

Planning (after 10 minutes)

What is the goal of this lesson? to be reviewing  
timetabling 10, 100, 100

How can I do this activity? tables

What am I good at that will help me? table

Do I have to really concentrate?  Yes /  No

Do I enjoy this activity?  Yes /  No

Do I have every thing that I need?  Yes /  No

Mid action reflection (share your ideas with someone)

Is the way I chose to solve this work working?  Yes /  No

Do I understand what I am doing?  Yes /  No

Am I making progress towards my goal?  Yes /  No

Is this activity interesting?  Yes /  No

Do I feel confident?  Yes /  No

Have I got everything I need?  Yes /  No

Notes about my mathematics learning (use this space for ideas from Monday

Wednesday or Thursday)

is to set it out right like this eg.

$$\begin{array}{r} 11 \\ \times 11 \\ \hline 11 \\ + 110 \\ \hline 121 \end{array}$$

general

activity one -

1	$\begin{array}{r} 23 \\ \times 33 \\ \hline 69 \\ +1690 \\ \hline 759 \end{array}$	2	$\begin{array}{r} 367 \\ \times 45 \\ \hline 1335 \\ +2680 \\ \hline 3015 \end{array}$	3	$\begin{array}{r} 168 \\ \times 52 \\ \hline 136 \\ +3400 \\ \hline 3536 \end{array}$
---	--	---	--	---	---

activity 2

a	$\begin{array}{r} 367 \\ \times 45 \\ \hline 1335 \\ +2680 \\ \hline 3015 \end{array}$	b	$\begin{array}{r} 339 \\ \times 44 \\ \hline 156 \\ +1560 \\ \hline 1816 \end{array}$	c	$\begin{array}{r} 357 \\ \times 85 \\ \hline 285 \\ +4560 \\ \hline 4845 \end{array}$
---	--	---	---	---	---

d

$$\begin{array}{r} 173 \\ \times 26 \\ \hline 438 \\ +1460 \\ \hline 1898 \end{array}$$

page 127

a	$\begin{array}{r} 288 \\ \times 3 \\ \hline 264 \end{array}$	b	$\begin{array}{r} 56 \\ \times 4 \\ \hline 224 \end{array}$	c	$\begin{array}{r} 497 \\ \times 7 \\ \hline 679 \end{array}$
---	--	---	---	---	--

Figure 6. Ann's work sample and reflective prompt

It also has to be noted though, that in this study the learning that was taking place here was often learning how to follow rules. When the students read the reflective prompt and asked themselves “Do I understand it?” They often answered “yes”, meaning they understood how to follow the algorithm to reach the correct answer. This type of understanding is described very succinctly by Skemp (1976) who describes this type of understanding as ‘instrumental understanding’ rather than achieving ‘relational understanding’ (p. 20). It is also important to note that the learning tasks set were not ones that would particularly develop number sense. The reflective prompt cannot begin to start developing number sense unless this concept has some validity in the teaching community, which is designing the learning environment and tasks within that environment.

#### **4.3.1.1 Exceptions to students reflecting**

Exceptions to these general findings did occur. Occasionally students would lose reflective prompt sheets. The teacher, not acting as an additional monitor of the procedure, exacerbated this. It was difficult for me to check that every student had been give a sheet and sometimes unmotivated students would not say when they had not been give a sheet. I would try to remind the students to complete their sheet, but generally I relied on the good will of the students, as I was not the teacher. Peter would sometimes not finish his sheet. In my notes I record:

*Peter not even filling his sheet in. So he's not going to change anything ...Peter messing around at the back has filled in his sheet as confident "know what he is doing" ... he didn't understand the concept at all – need for teacher modelling that it's okay to ask questions.*

### 4.3.2 Students were more Motivated

Another strong theme in the first half of the study is that the reflective prompt was motivating for the students. They were more motivated to engage in the number lessons, but the learning tasks set for the students throughout the study were developing their ability to learn mathematical rules and algorithms so when the students were more motivated, they were more motivated to complete the tasks set, not necessarily engaged in learning tasks that would have developed number sense. A more detailed look at how the reflective prompt motivated the students is explained below.

#### 4.3.2.1 Students' enjoyment increased

The students enjoyed being able to express their own ideas on paper. Before the project began, there was little opportunity for the students to do this. Through my observations in the class I saw that the students were in a large class of 32 students and they were seated in rows where the oral opportunities for the class were very limited. Overall the students did very little talking with the teacher. I noted:

*Children listen to instructions; the teacher is telling them that there is a relationship between decimals and fractions. She tells them that they need to learn basic relationships i.e.  $0.25 = \frac{1}{4}$ . Children were given two minutes to learn some of these that were on the board. Spending the time to explain procedure for solving mathematical rules.*

I observed many occurrences when students looked mortified at being asked in front of everyone to explain something and their body language suggested they were embarrassed when they got the question wrong. During one observation I noted:

*Today continued lesson on multiplying. Marked homework. Francis did not want to talk out loud so he said that he hadn't completed it to get out of it.*

They occasionally confirmed orally that they had heard what the teacher said and that was about it.

When I was discussing the implementation of the program, I asked them to always circle 'yes' or 'no' for each of the questions asked, but that completing the

notes section was entirely up to them. It is important to note that as the students were not directed that they had to express their feelings, it leads me to believe that when they did choose to write something down it was because they felt that it was a positive thing to do. It was satisfying that they were able to express different emotions such as, *I have done this since Year 2*. This was written down by Margaret in order to express some frustration at the learning material presented.

Certainly for some of the students it was a revelation that someone was really interested in how they found the number lesson. Simone explained in her interview:

*The teachers are really strict and you have to do what the teachers say. It [the reflective prompt] has made me more relaxed and I realised that the teacher wants to know that you understand.*

Simone also explained in her interview: *I liked it [the reflective prompt]; we were able to express our feeling and stuff.*

My impression from observing the students was that this satisfaction came from being made to feel that their learning process was important and this empowered the student in the learning process. Sarah also stated: *Its good filling it in cos you get to put down your ideas.*

Students, who were feeling negative for whatever reason, found particular benefit from expressing this fact through the reflective prompt. Delia wrote reflections on many occasions, in order to express the different difficulties that she was having. The excerpt in Figure 7 is a positive expression and it is evidence of the chance to reflect on her success.

**Week by 29/08/04 Reflective Prompt Name:** \_\_\_\_\_

Name: \_\_\_\_\_

Monday

**Planning (complete after 10 minutes)**

What is the goal of this lesson? \_\_\_\_\_

How can I do this activity? \_\_\_\_\_

What am I good at that will help me? \_\_\_\_\_

Do I have to really concentrate? Yes/No

Do I enjoy this activity? Yes/No

Do I have every thing that I need? Yes/No

**Mid action reflection (share your ideas with someone)**

Is the way I chose to solve this work, working? Yes/No

Do I understand what I am doing? Yes/No

Am I making progress towards my goal? Yes/No

Is this activity interesting? Yes/No

Do I feel confident? Yes/No

Have I got everything I need? Yes/No

Am I giving myself enough time? Yes/No

**Notes about my mathematics learning (use space on the back if needed)**

☺ I first thought I couldn't do it  
but I worked it out!

Figure 7. Expression of ideas on reflective prompt by Delia

The idea of the reflective prompt appealed to most of the students. The students were very excited to get their folders that held the reflective prompt sheets and they loved the colours on them. All 32 of the students also returned their consent forms to say they would be part of the project. Although it was the parents who had to sign the form, it would be logical to presume that if the students had gone home and had been negative about the project, then some parents would have decided not to sign it.

In the playground the students would come up to me at recess to talk about the project. In my notes I wrote:

*In the playground children are courteous. Sarah went up to me and started talking about taking a worksheet home. Enjoyed learning at home.*

The interviews were useful to reveal the student thoughts on the reflective prompt.

*I thought it would give me a chance to show me how to do maths an easier way yes it made me want to do it more (Diane).*

*I was a bit excited [it would] help us with our maths (Toni).*

*It [the reflective prompt] made me work harder. I get this feeling inside that I want to do everything right (Simone).*

*I felt sort of good about it. I don't really enjoy maths but I really like these reflection things. When Miss Smith told us that we would be having this reflective thing I actually got quite into it (Francis).*

#### **4.3.2.2 Students' confidence increased**

Some students found that the reflective prompt motivated them because it made them more confident. Through expressing their ideas and receiving feedback from myself it seemed to give the students the encouragement to tackle the number lessons more positively. Phillipa explained:

*It got your nerves out like putting your hand up I was more confident. Cos you took the sheets in, it made me more confident.*

Diane is also someone who seemed to gain in confidence as the study progressed. She gained confidence and her performance improved from being able to express her ideas in this private way. In one entry, included in Appendix M, she wrote:

*I found this term very good because improved the way I do maths. I have done more pages than ever and it really helped me using the reflection sheets it showed me what I needed to do and gave me a chance of finding new way to do math problems!*

This reflective prompt entry shows the uninhibited way that the student wrote. Shown in Figure 8 is an actual reflective prompt of Diane's. I have included this because it is informative to read the whole reflective prompt document and identify the uninhibited way that the student wrote.

Thursday 25.03.04

Planning (after 10 minutes)

What is the goal of this lesson? To review what prime numbers are, composite numbers and what factors are. Also to make a list of prime factors. Inc.

How can I do this activity? By knowledge of tables.

What am I good at that will help me? time: tables

Do I have to really concentrate?  No

Do I enjoy this activity?  No I really enjoy this ☺

Do I have every thing that I need?  No

Mid action reflection (share your ideas with someone)

Is the way I chose to solve this work, working?  No

Do I understand what I am doing?  No

Am I making progress towards my goal?  No

Is this activity interesting?  No very interesting ☺

Do I feel confident?  No

Have I got everything I need?  No

Notes about my mathematics learning (use this space for ideas from Monday Wednesday or Thursday)

Monday

23/03/04

I think I found out something?  
It really helps me.

I first write the sum and then try and figure it out. So I don't get lost in the sum I write down another sum that shows my working out eg.

$$36 \div (18 - 4 - 12) =$$

I do after that

$$18 - 4 = 14 - 12 = 2 \div 36 = 18 \text{ or}$$

$$18 - 4 = 14 \text{ then } 14 - 12 = 2 \text{ and then } 2 \div 36 = 18$$

Great  
☺  
this is so good.

Figure 8. Diane's reflective prompt entry



Through classroom observation I would also identify Russell as another student who really grew in confidence as the study progressed. He explained in his interview,

*It [the reflective prompt] helped me to understand maths. It made me believe that I could do this.*

The teacher's completed diary of these experiences was very valuable data as this was another adult perspective on the study. This entry was written very near the end of the study. After finally reading their comments at my request, Miss Smith stated:

*It was interesting reading the children's responses on their reflection sheets. Children have not made verbal comments to me. I wonder if this study has made them feel more confident.*

The students gained confidence in not just been judged from their results but from having their individual learning process valued.

#### **4.3.2.3 Exceptions to increased motivation**

In the class there was a small group of about five boys who became disinclined to complete the reflective prompt as the study progressed. They were generally courteous boys and I do not think that their lack of interest was just to be difficult. After observing them closely, I came to the conclusions that because they did not need much help, they felt that they did not need the reflective prompt for that purpose. They got high scores in their work so they also did not want the work to change. Jason explained his feelings about the reflective prompt in the interview:

*Because it really just asks me questions and I was doing my maths anyway. Yeah well I understood it [the mathematics] so it [the reflective prompt] didn't really matter... it didn't really help me that much, I didn't think it was that good.*

Overall they did not show the interest level of the other students. Jason, who was one of these four boys, honestly writes in reflective prompt

*This term the reflective prompt has not helped me in my maths at all.*

### **4.3.3 Students Directed towards Different Learning Strategies**

This was not a very strong theme but it did gradually emerge to be an effect of the reflective prompt. This area is a vital theoretical benefit of the reflective prompt. Its aim is clearly to empower the learners so that they may act like an expert; that is to use the most effective learning strategies. My classroom observations did not reveal any radical empowerment of the learner. The students were not in any position, after identifying certain personal needs that were not been met, to change the classroom culture. The teacher's strong personality may have had something to do with this. The interviews reveal however, that the students definitely perceived that one effect of the reflective prompt was that it directed them to use specific learning strategies.

Some of the learning strategies that the students were directed to use were quite diverse, and below I have highlighted some of the learning strategies that the reflective prompt reminded or prompted the students to use. It is important to note that there was not one major learning strategy that was implemented more than the others, but there was evidence that the classroom observations and statements in the interviews highlight that the reflective prompt did direct them towards using certain learning strategies. The term 'learning strategies' is used in a very broad sense and it takes into account strategies used to address cognitive, motivational and resource issues. It also needs to be reiterated that the learning that was normally taking place was often learning how to follow rules to complete tasks with closed questions. I have included an example of this type of mathematics exercise in Figure 9.

The style of task set meant that the students did not have many independent learning decisions to make and even when they used more effective learning strategies to complete the required tasks, often this did not mean that number sense was developed. The effective learning strategies were implemented either as a result of myself prompting them after reading a response, or the students changing their learning strategy independently, and I have provided evidence below of these two routes that the students took.

MULTIPLICATION

4-11-04

Set 94

$\begin{array}{r} \$3.08 \\ \times 35 \\ \hline -15.40 \\ 92.40 \\ \hline \$107.80 \end{array}$	$\begin{array}{r} \$6.07 \\ \times 48 \\ \hline -26.42 \\ 292.80 \\ \hline \$279.22 \end{array}$	$\begin{array}{r} \$8.03 \\ \times 65 \\ \hline -40.15 \\ 491.80 \\ \hline \$521.95 \end{array}$	$\begin{array}{r} \$5.87 \\ \times 97 \\ \hline -35.49 \\ 56.30 \\ \hline \$81.79 \end{array}$	$\begin{array}{r} \$7.08 \\ \times 84 \\ \hline -28.24 \\ 564.80 \\ \hline \$593.04 \end{array}$
---	--	--	--	--

Set 95

$\begin{array}{r} \$7.28 \\ \times 48 \\ \hline -58.08 \\ 90.40 \\ \hline \$348.48 \end{array}$	$\begin{array}{r} \$7.84 \\ \times 38 \\ \hline -47.04 \\ 235.20 \\ \hline \$282.24 \end{array}$	$\begin{array}{r} \$5.93 \\ \times 84 \\ \hline -23.72 \\ 474.40 \\ \hline \$498.12 \end{array}$	$\begin{array}{r} \$6.87 \\ \times 64 \\ \hline -27.48 \\ 412.20 \\ \hline \$439.68 \end{array}$	$\begin{array}{r} \$8.34 \\ \times 57 \\ \hline -58.38 \\ 417.00 \\ \hline \$417.38 \end{array}$
---	--	--	--	--

Set 96

$\begin{array}{r} \$58.79 \\ \times 37 \\ \hline -41.53 \\ 2063.70 \\ \hline \$2145.23 \end{array}$	$\begin{array}{r} \$74.38 \\ \times 65 \\ \hline -371.90 \\ 4462.80 \\ \hline \$4834.70 \end{array}$	$\begin{array}{r} \$12.83 \\ \times 98 \\ \hline -333.98 \\ 5834.70 \\ \hline \$6223.58 \end{array}$	$\begin{array}{r} \$59.14 \\ \times 67 \\ \hline -417.48 \\ 578.40 \\ \hline \$395.82 \end{array}$	$\begin{array}{r} \$12.57 \\ \times 45 \\ \hline -212.85 \\ 702.80 \\ \hline \$145.65 \end{array}$
---	--	--	--	--

Set 97

$\begin{array}{r} 38.35 \\ \times 23 \\ \hline 109.95 \\ 727.00 \\ \hline 236.05 \end{array}$	$\begin{array}{r} 31.73 \\ \times 48 \\ \hline 1292.88 \\ 149.20 \\ \hline 2241.58 \end{array}$	$\begin{array}{r} 38.72 \\ \times 74 \\ \hline 154.88 \\ 710.40 \\ \hline 285.28 \end{array}$	$\begin{array}{r} 35.47 \\ \times 26 \\ \hline 392.82 \\ 309.40 \\ \hline 1702.22 \end{array}$	$\begin{array}{r} 58.35 \\ \times 64 \\ \hline 233.40 \\ 3501.00 \\ \hline 3734.44 \end{array}$
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Figure 9. Debbie's mathematics work.

#### 4.3.3.1 Researcher directing students to use a different learning strategy

The students wrote down in their reflective folders when they were having problems with something and, as I read them every week, I was able to build up an idea of how they perceived they were operating. Sometimes I was able to offer some advice in order to support them. Margaret felt that, *I think it helps to write it down and get help.*

As I was not the class teacher and was not in charge of structuring their daily program, I was not able to take these comments and start changing the activities that they were presented with. All that I could do was give small suggestions. Shown in Appendix M is John's reflective prompt. John did not understand what remainders were nor how to express the remainder as a decimal. He did not understand the lesson and he was able to say in the prompt: *I am not understanding what to do with remainders.*

I was able to give him a written explanation and then I chose to back it up orally with a fuller explanation. In his final interview John confirmed that he had found this process useful when he stated:

*one time when I was doing this sum I forgot to put in the remainder and the reflective prompt; you showed me how.*

Delia did not find the mathematics easy and she was very under-confident and did not like to express her views normally. The students were given one lesson on the subject of prime factor trees. The aim was to teach all the students about prime factor trees. There was no assessment material available concerning the students' abilities in these areas. Delia was able to identify and record in the reflective prompt while completing this lesson that she did not have conceptual understanding of prime and composite numbers, and that was making it difficult for her to complete the prime factor trees. I was able to read this and tried to offer some elaboration strategies (McKeachie, Pintrich, Lin, & Smith, 1986), which might help her build up her own conceptual knowledge. Of course it would have been better educational practice to provide more practical activities and reflective discourse in class to build these ideas.

The class mathematics curriculum moved on to the topic of equality and inequality, so Delia was left with these conceptual problems and no record would be made of this. I have included her reflective prompt in Figure 10 as it is useful to observe the end result and it shows that she was able to express her thoughts in the various sections of the reflective prompt.

Mid Action Reflection after 30 minutes

Is the way I chose to solve this work, working?  Yes  No

Do I understand what I am doing?  Yes  No

Am I making progress towards my goal?  Yes  No

Is this activity interesting? Yes  No

Do I feel confident?  Yes  No

Have I got everything I need?  Yes  No

Am I giving myself enough time?  Yes  No

Notes about my mathematics learning (use extra paper if needed)

Thursday

Planning after 10 minutes

What is the goal of this lesson? to make factor trees

How can I do this activity? not sure

What am I good at that will help me? nothing

Do I have to really concentrate?  Yes  No

Do I enjoy this activity? Yes  No

Do I have every thing that I need?  Yes  No

Mid Action Reflection after 30 minutes

Is the way I chose to solve this work, working?  Yes  No

Do I understand what I am doing? Yes  No now I do

Am I making progress towards my goal? Yes  No sort of

Is this activity interesting? Yes  No

Do I feel confident? Yes  No sort of

Have I got everything I need?  Yes  No

Am I giving myself enough time?  Yes  No

Notes about my mathematics learning (use extra paper if needed)

yes okay  
I agree what takes it hard  
Sometimes I'm not sure if a number is a prime or not. Same with a composite.  
← I will try to help you with this

Figure 10. Delia's reflective prompt

#### **4.3.3.2 Students acting independently to use a different learning strategies**

In the observed classroom the students were quite dependent upon the teacher in their learning situation and they really had only a few areas of learning that they were able to change through their own actions. Diane became more focused on her mathematics activity shortly after the prompt was introduced. She realised that she needed to concentrate after asking herself the question on the reflective prompt: *Do I really have to concentrate?*-Yes. I noted the classroom observations, which explains her actions.

*Working on number patterns. The open plan classroom makes it difficult sometimes as the other class may be talking while the class is trying to work quietly...Despite the prompt earlier (in the first cymbals) removing concentration, today the prompt was less invasive and worked better. Diane said, "I worked really well today. I found out the numbers on the grid. I worked harder than usual" Diane really putting in a lot of effort.*

I could clearly observe the extra effort that had occurred at the same time that the prompt was introduced. The interviews showed that the students perceived that the reflective prompt was useful in directing them towards a more efficient learning strategy.

*It [the reflective prompt] made me want to learn maths more because I write down that I haven't accomplished something and then I change it (Elle).*

*It [the reflective prompt] helps me organise my thoughts more (David).*

*Whenever I look in my desk and see my reflection sheet and when I open it when you aren't here for maths I look at it and then it reminds me for homework I need more practice for times table so I go home and do that (Francis).*

*My scores are getting better. I was failing miserable and now I'm average. I'm concentrating more and I'm having more fun. The way things maths is being taught and concentrating I realise what my goals are (Russell).*

*In the first maths session I was hopeless at everything and you gave the folders and now things are more easy for us (Francis).*

Jane's reflective prompt revealed that she used the note section to record some action that she felt needed taking with regards to her number work. It had been filled in after completing some work on long multiplication. The students often marked their work with the teacher calling out the correct answers. The students then simply marked these right or wrong. In this example she is noting how she hasn't marked this properly and decides that she will review it at home and get her parents to act as a resource to help her. She wrote in her reflective prompt:

*I have gotten a little bit confused when we were marking our work. So I stopped. I think I'll have to review them tonight (get my parents to give me sums).*

On another occasion I watched Daisy complete the reflective prompt just before attempting her mathematics. The reflective prompt encouraged her to use cognitive strategies to plan and think of the goal of the lesson. In this instance she decided that the focus should be on the decimal aspect rather than division and so changes the goal of the lesson:

*When observing Daisy she listens to the teacher. The children were given no introduction. They just had to start work on the MTS maths book after been given the page number. The lesson was about dividing decimal numbers. The teacher was sitting at the desk marking. The class were noisy next door. The bell rang for the first completion of the reflective prompt. Daisy had to fill in what the lesson was about. Firstly she wrote division. Then I observed her stop, think, then change her answer to decimals.*

#### **4.3.3.3 Exceptions to different learning strategies being used**

A few students were worried to express their thoughts on the reflective prompt. From my notes in my observations there is the example Phillipa put that she understood everything on the reflective prompt:

*Phillipa has filled in on R.P [reflective prompt] that she has understood everything when she didn't. When I asked her she blushed and said "kind of " even though I had been sitting explaining it to her just a second ago.*

When I then asked her about her mathematics work using 'greater than' and 'less than' signs she clearly did not understand. I do think that may be the culture

within the class which caused some of this anxiety, in that she felt scared to express her inadequacy.

#### **4.3.4 Students were Resigned to the Fact that Expressing their Thoughts did not Change the Learning Tasks**

This effect was a very strong theme in the study. The students had enthusiastically taken on the expert learning process, and completed the reflective prompt in every number lesson. They were motivated to continue completing the reflective prompts, even at the end of Term 4, and I noted:

*Tony filled in [reflective prompt]. He knew what to do – got straight on. All knew what they were doing. Filled it [the reflective prompt] in without any problem.*

There was evidence of increased motivation at the earlier stages of the study, and they were directed towards effective learning strategies by the reflective prompt. The students could change small areas, and I have already identified some students filling in the prompt saying: *I must remember a red pen.*

Despite these effects though, the expert learning process did not greatly impact their classroom learning experience. To illustrate this point it is worthwhile to focus on Francis's response. He was able to realise that he was having problems, which of course is very important, and he expressed this in his reflective prompt: *I am finding this very hard.*

When this happened in this very teacher-dependent learning setting, Francis was unable to change his learning situation and find ways of engaging in tasks to aid understanding, which is what an expert learner would do. Instead he and other students were reliant on the teacher to plan what was to be learnt. The students accepted this situation and were resigned to the fact that their learning environment remained where they were as passive learners. From my notes I wrote:

*The reflective prompt doesn't get much use, as the children are just passively absorbing. Difficult to fill in the reflection sheet [reflective prompt] in this case as the teacher is talking mostly. Weaker children just seem to accept that they will not understand everything.*

One individual example of this is Jill. She expected that, when she identified she was not working like an expert learner, it would have no influence on the



classroom proceedings. When the students were being taught about multiplying hundreds, tens and units by tens and units I noted that in her reflective prompt she wrote: *Do I enjoy this activity - No; Do I feel confident – No*. In my notes for that day I noted how this lack of confidence expressed in the reflective prompt did not effect the classroom experience for Jill.

*Marking the long multiplication homework. Jill gave the answer. It didn't make sense. Teacher very quickly moved on to Joshua who's left book at home so Bill, the bright boy, was asked.*

*Jill now solving problem on the board without their books. Jill made a mistake went back to her book (the work has been done as homework Mum may have helped?) then came back and changed it. Next lesson moving on to decimals regardless of how children got on today.*

Jill accepted this situation and there was no evidence of any further action being taken.

Another example of the learner being resigned to the fact that the reflective prompt expressions would not change anything is taken from Catherine. The students were learning how to multiply by 10, 100 and 1000. In my notes I wrote;

*Children are all required to multiply two numbers that are together, and then add the number of 0's that there are. All worked on the same. Learning is directed at them. Do this by doing that. In this instance learning has not changed by learning reflection.*

In Catherine's reflective prompt, shown in Appendix M, she reflected that: *I find it boring when the teacher explains cos I already know how to do it.*

Despite the student noting down that she had done some long multiplication and in the above example, explains that she knows how to do it, no consideration of this was taken. The class continued to be taught long multiplication in the next lesson. In my notes I described this lesson;

*It was my turn to teach long multiplication. This was to be introduced to all the children at the same time. They started with revision of tens and units multiplied by units. Most children completed this or at least worked quietly. They filled in their reflective prompt at the beginning of the lesson.*

Jill's comments had made no impact on the tasks but she did not express any emotion or take any action as a result of this situation. In one of the plenary sessions, Leah did ask: *What should I do if I write down this lesson is boring?*

I answered that she could make it into a competition. Of course another answer would have been for the teacher to provide more interesting mathematics activities if motivation was a problem. Yet again though, I had not asked the teacher to change her teaching style or content so I could not include this in my suggestion to the teacher. When the student wrote down that they were having problems with understanding the mathematics or the work was too boring and easy, it was not read by the teacher and she continued teaching the content as planned on her teaching schedule.

From the teacher's diary it suggests that possibly she did not read the students' work, as she thought they were not capable of engaging in this thinking process. She wrote, *I wonder if children actually think about what they are doing.* Overall therefore, the students who had been expressing their ideas saw no real changes to the tasks set in the classroom and teaching approaches generally. In the final interviews the students did express that the reflective prompt was not changing things dramatically. Russell explained:

*You already know how to do the stuff. You should be able to just write it down if you've understood or you have problems not just keep writing down the same things, writing down the same thing is getting boring.*

Mary also stated in her interview: *we did it all last term and now its getting boring.* When I asked Ann if she found the reflective prompt motivating, she answered, *at the beginning but now you just keep on going.*

Ann was very bright and in her interview she describes this feeling that the teacher was focusing on delivering a standard curriculum and not meeting their needs in order to learn. In the interview she was explaining how she did not think Miss Smith read the reflective prompt because she was not interested in their abilities and that in Year 4 they were streamed for mathematics (the students called this streaming, 'switch maths') and she felt that she was not being stretched.

*I'm not being offensive. Some people don't read it [the reflective prompt] She [Miss Smith] does not care about us. She just goes on about go on to the challenge [extension work for early finishers] then she spends time with the others. You pretend that you are not listening so that she will ask you. If we had had a better teacher I would have loved switch maths [streamed maths] much more because they were at your grade level. Doing Year 7 and 8 we could not almost do it and that is what I like. We have learnt long multiplication before in Year 4.*

Elle also reflects how they were streamed in Year 4 compared to this class where they are now are all set the same activities.

*In Year 4 we had a teacher who saw what we are capable of. Miss Smith just ignores that. We just do the same thing. That's what makes mathematics boring. If we had something different it would be better.*

The expert learning process, which incorporated the reflective prompt, did not empower the learner sufficiently so that the teaching was altered to take into account the student's thoughts, ideas and misconceptions. This powerlessness of the students is typified in the following except from my record:

*The teacher was going on a course, so a relief teacher and myself were taking the class. I had been asked to teach the children to follow the rule when solving number sentences. Some of the children were questioning me about whether you should always add before subtracting rather than work left to right because BIMDAS followed literally, would inform you to do this. I encouraged them to consider the understanding of this rule of order. A lively discussion followed between the children in the class, the relief teacher and myself. The children began to realise that really the main emphasis of this rule was to do multiplication or division before addition and subtraction, particularly because of the properties of these operations. The relief teacher joined in with the discussion saying that she saw multiplication and division like twins having more power over addition and subtraction twins and therefore needed to be solved first. It was a very interesting discussion and started the children identifying the properties of addition and subtraction and multiplication and division. On her return Miss Smith did not want these issues discussed and instead reiterated that she wanted the children to be taught to follow the rule BIMDAS; that is to do brackets first, then indices, then multiplication, then division, then addition, and then subtraction.*

The teacher remained the more powerful factor in determining what the students were taught. The students were resigned to this and in this case study the

teacher's beliefs and teaching styles remained unchanged despite the implementation of the expert learning process. An exception to this took place after the final interview with Ann. A week later she had identified the following responses in her prompt as below:

*Do I really have to concentrate? No.*

*Do I enjoy this activity? No.*

*Do I have everything I need? Yes.*

*Do I understand what I am doing? Yes.*

*Is this activity interesting? No.*

She then went up to Miss Smith and said that their work that was being set was too easy for her. Miss Smith looked quite shocked and said that Ann could have more difficult work. I noted this in my classroom observations.

*Lesson on dividing with decimals. One of the brightest children Ann, asked Miss Smith for extension work saying that this was easy. Starting to be empowered as a learner. Margaret then asked as well.*

It is a shame that it happened near the completion of the study, as it would have been interesting to see what would have happened next.

#### **4.4 Summary of Effects**

Figure 11 shows a summary of the main effects of the expert learning process. The themes which were created using content analysis – the procedure for this shown in more detail in Appendix N – were not presented in any particular order. They do represent the main observations made as to the effects on Year 6 students using an expert learning process, which was designed to promote number sense development.

**Main Effects on Year 6 students using an expert learning process designed to promote number sense development**

Students reflected throughout number lessons

Motivation to learn about mathematical rules and algorithms increased

Students directed towards more effective learning strategies when learning about mathematical rules

Students were resigned to the fact that expressing ideas did not change learning tasks

Figure 11. The effects on Year 6 students using an expert learning process

#### **4.5 Research Question 2**

***Did number sense performance of the Year 6 students improve through using an expert learning process?***

This question had been designed to support the qualitative data collection. The expert learning process had been designed to promote number sense so it is therefore logical that I would be interested to find out if number sense improved. As there was a number sense test available which had been used in an international study, (McIntosh, et al., 1997) I had a reliable measure, which would be able to quantify any number sense improvement. I had therefore decided to quantify any number sense improvement in terms of increased performance in the number sense test. I decided to conduct a one group, pre-test – post-test design.

The test implemented had been used by Year 5 students in the international study, so it was not possible to directly compare the results with the international study as these students were Year 6. I was really interested in the change after completing the expert learning process, so the students being a year older than the original design was not seen as a problem.

Analysis concentrated on the change in scores from the pre-test taken by the students before the study began and the scores from the post-test taken by the Year 6 students at the end of the study. The raw scores for the students' are available in

Appendix B. This simple analysis was designed in this way as it was meant to be a confirming measure for the qualitative results.

Figure 12 reveals the students' pre-test scores on the number test. The mean on this test was 20.63. This compares with the mean of Year 5 in the international study of 18.40. As mentioned previously the students are one year older so a direct comparison of score is neither possible nor necessary. It does give some indication however of the Year 6 students' standard of number sense ability. The standard deviation on the pre-test was 5.88, compared to 5.10 in the international study.

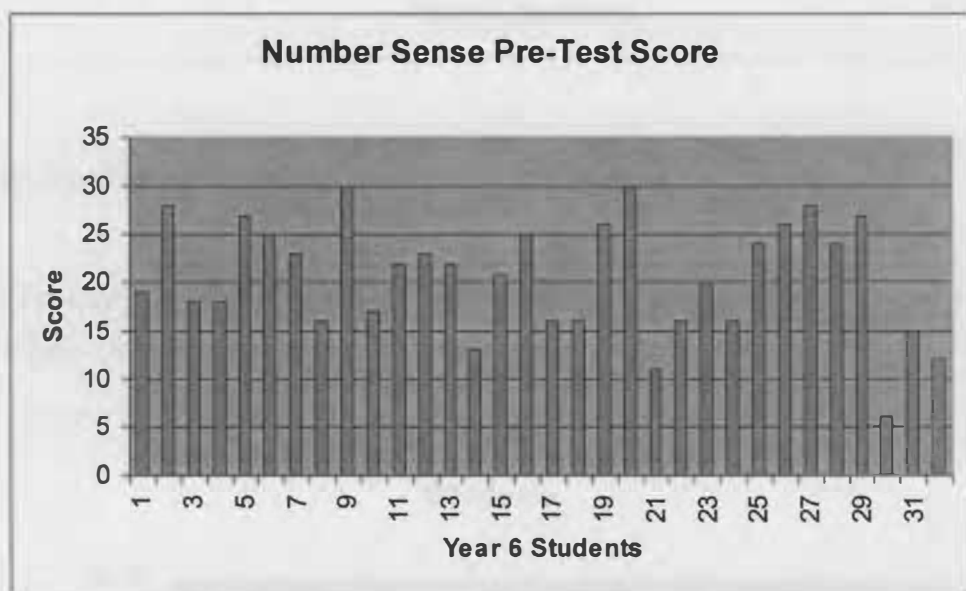
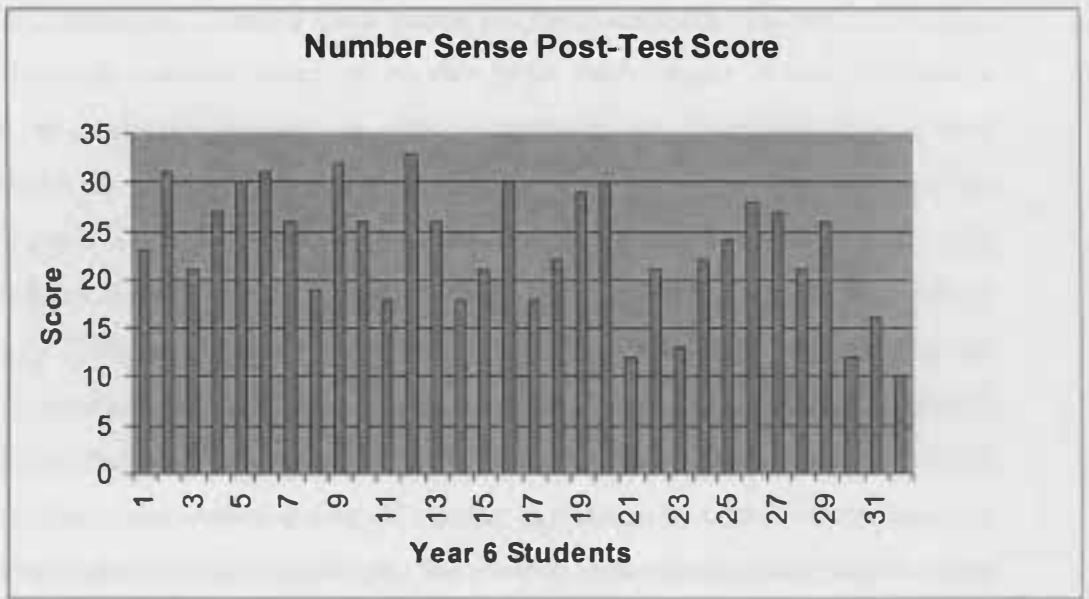


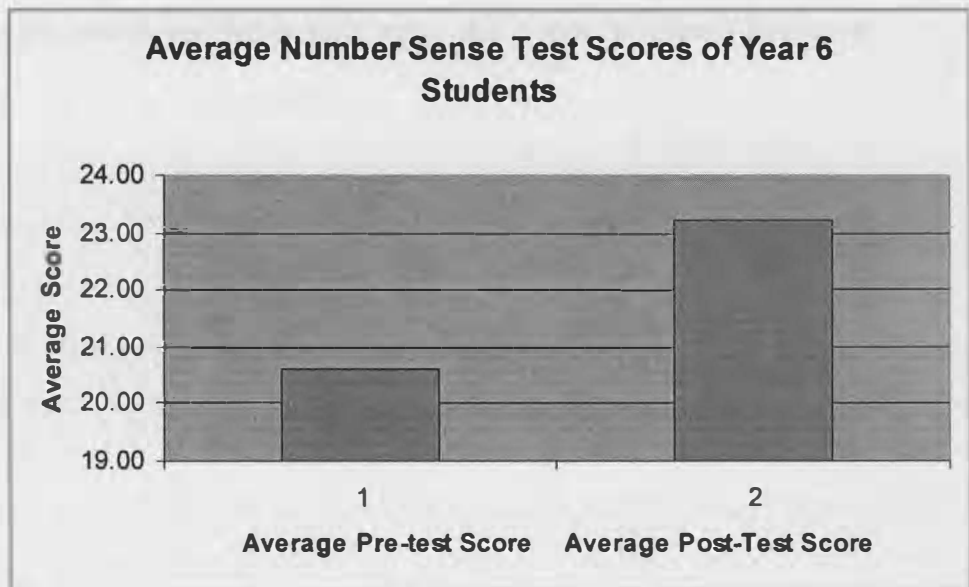
Figure 12. Number sense pre-test scores of Year 6 students

Figure 13 shows the students' post-test scores. The mean in this test was 23.22 compared with the Year 5 score in the international study of 18.40. The standard deviation of 6.26 compares with 5.10 in the international study.



**Figure 13.** Number sense post-test scores of Year 6 students

The analysis was focussed on the change between pre-test and post-test scores. Figure 14 shows that the mean change in test scores was 2.59.



**Figure 14.** Average improvement in number sense test scores

The changes in mean scores, showed only a slight improvement in number sense performance. Due to the students being five months older, one would have expected the students to have gained some improvement in number sense ability due

to natural maturation, therefore these results led me to conclude that the intervention did not have any marked effect on number sense performance. It was possible to consider the qualitative findings in order to speculate why there was only a small improvement in number sense. The qualitative data collection revealed that the teacher's goals for the lessons were rote learning of mathematical rules, so that even when students became more engaged in their learning, number sense was not an intended or likely outcome of the learning experience. It was also revealed that she did not acknowledge the students' reflections when planning her teaching, so she did not cater for their individual needs. This meant that the students were not able to further develop their understanding of number as defined by constructivist learning. These observations would explain why the number sense performance did not show any significant increase.

There are limitations to the design and it would not be possible to generalise from this result. There may have been other reasons for the change in scores other than the effect of the expert learning process (Johnson & Christensen, 2004), so it really is important that the results are seen in conjunction with the other data collection. The small improvement of 2.59 in the students' number sense score supports the conclusion that number sense ability was not greatly improved.



## CHAPTER 5: CONCLUSION

The aim of this study was to explore the effects of implementing an expert learning process into a real classroom. The expert learning process was a set of reflective prompts designed to prompt the students to ask themselves questions that expert learners would ask. It was completed on paper at various times throughout the lesson with a whole class discussion generated by reflective questions about their learning, structured to occur at the end of the lesson. As I was interested in researching primary mathematics I selected a Year 6 class, which was in the primary age range.

The aspect of mathematics, which it was to support, was number sense. This was chosen as, although number instruction has always been important, number sense is now emerging with greater importance in the curriculum. It was also a more specific topic, rather than trying to consider the whole mathematics curriculum, and this made it more manageable for this relatively small study.

Recent research is becoming clearer as to what sort of learning experiences students need to have in order to develop number sense effectively. This awareness allowed me to evaluate and assert that the expert learning process should be beneficial to number sense development.

I took a case study approach to the research as this was an exploratory study and I was interested in describing how the implementation of the reflective prompt evolved, focusing on what happened to the learning experiences of the students. Due to the fact that I was the only researcher and that this was a newly created implementation, I felt that it was the most productive path to gain in-depth rich material about one setting.

In order to answer the first research question the data was collected qualitatively through classroom observations, interviews of the students, the written reflective prompts, and collected work samples. Following this procedure I was able to describe the effects on the Year 6 students' learning. These effects are outlined below.

The reflective prompt was able to provide a structure which enabled the Year 6 students in the class to act as self-regulated learners. Through a low maintenance reflective prompt they were engaged in a process where they were thinking metacognitively in the planning stage of the class and mid-way through the lesson. They were asking themselves questions specifically concerning cognitive, environmental and resource management strategies and responding to these. The structure was easy for the students to understand and they were able to do this independently. This implementation was successful in all types of number lessons. The actual time that the students completed it was somewhat flexible but the self-questioning was always part of the lessons. Due to its brevity the task was not laborious for the students and its implementation was continued. This action was identified as very important in much of the research literature (Zimmerman, 1998; Garofalo & Lester, 1985; Herrington, 1990).

The expert learning process was very motivating for the students. It was described to them as a learning experience where they would be in charge of their learning and that it had the aim of increasing the effectiveness of their number learning. This was inspiring to them. They found the project novel and enjoyed being able to express their feeling to an interested adult. For many of the students it helped them become more confident as they managed to enjoy and explore their number learning more; rather than just focus on test scores which was the only real focus in the pre-study classroom environment. It also made the students feel that their learning experience was important. This was especially motivating for the students who did not receive high test scores. Ames (cited in Bruer, 1994) asserts that this focus on learning is the best approach to take, stating that many classroom practices appear to value “performing over learning, thus negatively influencing students’ ideas about intelligence and learning” (1994, p. 276). She is now “trying to create a classroom that emphasises the process of learning, reward, effort, focussing on children’s individual progress” (p. 277). The reflective prompt guided classroom practice towards valuing the student’s learning experience – the process rather than the product.

The reflective prompt directed the students to think about whether they were behaving as an expert learner would. Where they answered ‘yes’ they could continue on. Where they answered ‘no’ in the reflective prompt it did make the students think

about how they could use a more effective strategy. They were directed to consider more effective cognitive, motivational and environmental strategies. As the number work was often about following rules the conceptual understanding was quite limited, so when they answered the question, “Do I understand it?”, it was normally in the context of “Do I understand the procedure?”. They sometimes either stated the problem that they were having in their learning and I was able to offer some small suggestions to guide them to a learning strategy that would enhance their learning, or at other times they were able to actually change it. They were in a dependent learner situation so the aspects that they were able to change were quite limited.

The last effect identified was that towards the end of the study students became resigned to the fact that the learning tasks in the classroom would not change regardless of what they expressed in the expert learning process. The teacher assessed the students on topic tests taken periodically and she did not believe that students’ thought process were important when planning her teaching. Therefore she did not read the reflective prompts and continued her teaching activities regardless of what was written. The students were being told that expert learners made sure that they were pursuing effective cognitive, motivational and environmental strategies. They generally completed the self-questioning sheet reflecting on whether the strategies were working. Their comments reflecting these thoughts however, were not being read by the teacher, so they were being presented with syllabus-prescribed activities rather than ones that would have met their cognitive, motivational or environmental needs in order to learn effectively. They were also in a very dependent learning situation so they were unable to ‘get up’ and do something about it. As the students were Year 6 they often would not know what to do when they identified that they were not working like an expert learner.

At this age it appears in that the teacher’s role may be paramount in identifying problems in understanding concepts and directing the learning experience accordingly. For this reason, unlike with adult learners, it may be essential that the teacher is observing the thoughts of the students and directing them towards suitable learning activities. As this did not happen in this case study the students became resigned to the fact that their completion of the reflective prompt was having little or no impact. They tended to become resigned that they were not really going to be in a position to move towards acting as expert learners in the classroom.

In this study I was particularly interested in exploring how the reflective prompt may affect number sense development. I had wanted to focus on number sense due to the emerging importance of number sense development in the mathematics curriculum. I had been able to identify links between what the expert learning process wanted to promote and what research findings stated would promote number sense. These close links made me decide that it was worth investigating whether the reflective prompt would have benefit in a number lesson in order to develop number sense. In the second research question I therefore focused on analysing if there was any increased number sense performance and I was able to answer this question quantitatively using a number sense test (McIntosh et al., 1997).

The analysis focussed on the change between pre- and post-test scores. The mean change in test scores was 2.59. There was only a slight improvement in number sense performance. It was possible to consider the qualitative findings in order to speculate why there was only a small improvement in number sense. The qualitative data collection revealed that the teacher's goals for the lessons were the rote learning of mathematical rules, so that even when students became more engaged in their learning, number sense was not an intended or likely outcome of the learning experience. It was also revealed that she did not acknowledge the students' reflections when planning her teaching, so she did not cater for their individual needs. This meant that the students were not able to further develop their understanding of number as defined by constructivist learning.

The two research questions had been created using a combined methodological approach so that they would increase the internal validity of the study. It became apparent that as well as reading the findings of the questions separately it was useful to also consider the two findings as part of the whole exploratory study. The quantitative data showed that number sense performance did not improve much, and this supports the findings of the qualitative data.

In Figure 15 I have created a network diagram (Johnson & Christensen, 2004) to show the overall findings based on the research questions. It highlights the effects of the study and it shows that overall number sense performance only increased slightly in the classroom setting that I studied.

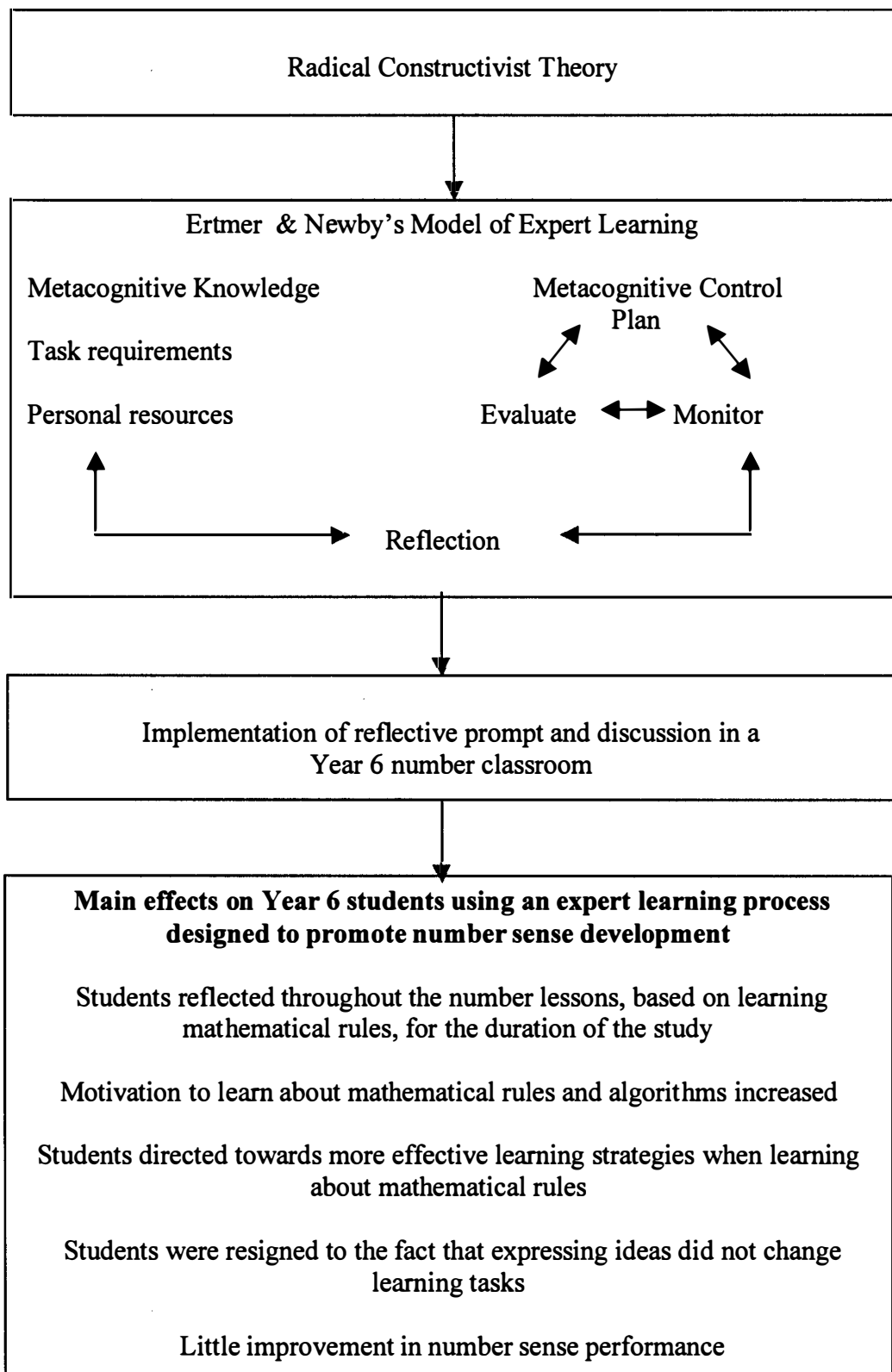


Figure 15. Effects of an expert learning process on Year 6 students.

It is important to acknowledge however that there may have been potential for developing number sense if the learning activities that were presented to the students were changed. The reflective prompt encouraged the students to act as a self-regulated learner throughout the number lesson and this reflection is an important component of number sense development. McIntosh et al. (1997) clearly state that

reflection is a process which is closely connected to good number sense ... every teacher should aim for a classroom climate where reflection and evaluation are important elements in the work. (p. 44)

The reflective prompt encouraged them to think about their number work, as they were about to embark on it, and midway in each lesson consider their way of working. The plenary session questions were provided and a culture could be created where students reflected back on the whole session, even if this was not successful in this setting.

The expert learning process was motivating for the students. The literature on number sense teaching does not explicitly talk at length about motivating the students but at all stages describes creating activities that fully engage the learner. In this way it leads me to believe that anything that motivates the learner to be more involved must be beneficial to number sense development. The students greatly enjoyed expressing their reactions and ideas on the prompts.

Number sense activities are described as ones where an engaged learner is involved in appropriate sense making activities within the classroom. The reflective prompt allowed the students to reflect on whether they were understanding the mathematics or not. If the word 'understanding' was defined and explained to the students to mean a deep conceptual understanding, they could identify when they were not making sense of the mathematics and either find more effective learning strategies independently or express their lack of understanding. Then their teacher would be able to suggest ways that would aid their understanding.

Lastly, if the students' thought processes were being valued by the teacher, this would have been useful for developing number sense. Assessment of the pupils' understanding has been identified as crucial for number sense development (Askew et al., 1997) and the reading of the reflective prompt facilitates this process. By not understanding the students' thought processes the learning activities will not be matching the learners' needs in order to build up the necessary knowledge networks.

In conclusion therefore, the effects showed that in this study the reflective prompt could be introduced into a mainstream classroom enabling students to ask the questions that expert learners ask. The key ideas that reflection can be built into an integral part of number lessons may be of use to researchers who are interested in effective learning in any domain. It would now be worthwhile to conduct a more extensive study to find out if generalisation of the findings is possible.

Also in this study, the reflective learning process was halted once the students had expressed their thoughts and therefore there was no real impact on the learning experience. At that point the influence of the reflective prompt was limited due to the teaching style of the teacher. She used testing of topics periodically as her means of assessment and, as she did not listen to the students' thought processes when planning her activities, their reflections had little or no impact. This leads me to suggest that there would be an interesting avenue for future research to determine the teaching approach to be used in the research and observe what would happen to number sense development if the teacher had acknowledged the students thoughts. If after reading about their misconceptions or their lack of understanding and had changed the activities this may have greatly improved number sense development. For instance, in this present study their teacher did not facilitate any quality end-of-class discussion and this greatly inhibited the reflective prompts' effectiveness. If the teaching approach trained the students to share mathematical thoughts processes with their peers and the teacher, the expert learning process may be greatly enhanced. Lastly if we are truly going to see an improvement in number sense development the goals of the classroom have to be clearly set on developing a robust understanding of number. If all these aspects were put in place it may mean that the students really are behaving and thinking as expert learners and number sense may greatly improve.

The methodology was very useful in this study but I think there is still much work to be done in analysing how the expert learning process can work most effectively in a mainstream classroom. Qualitative methodology would be the most suitable in this future research in order to further explore its use in developing number sense.

It is very important to acknowledge that this was only one response to the use of the reflective prompt in one setting. Although I maintain that the study has internal validity, an important avenue to investigate is to research what happens when the reflective prompt is implemented in multiple settings in order that it may be possible to engage in generalisation. This then is another suggestion for future research.

The main limitation of the study in retrospect was the inability to record the effects of the expert learning process where the teacher responded to the students' reflections. The teacher did not provide feedback after the students had presented their reflections. This restricted the possibilities that may have taken place in order to develop number sense.

Looking forward, I believe that it is important to continue focussing on instructional design that acknowledges all the areas identified by the Ertmer and Newby model (1996). If students' needs are met in all these areas, including differentiated cognitive practical activities, suitable environment, and appropriate class discussions, it may be possible for students to receive maximum benefit from being part of such a classroom setting. From a number sense perspective students should then develop a love of number and continue to use the number skills they have learnt in the classroom long after they have moved on into the real world as an adult.



## REFERENCES

- Angus, M. & Gray, J. (2000). *Research preparation: Methods of research (Print version)* [Brochure]. Perth: Edith Cowan University.
- Askew, M. (2004). Learning together: Effective teaching of numeracy. In A. McIntosh & L. Sparrow (Eds.) *Beyond written computation* (pp. 171-181). Perth: MASTEC, Edith Cowan University.
- Askew, M., Brown, M., Rhodes, V., Wiliam, D. & Johnson, D. (1997). *Effective teachers of numeracy*. London: King's College London.
- Askew, M., Bibby, T., Brown, M., (2004). Developing number sense: The interplay of the individual and the social. In A. McIntosh & L. Sparrow (Eds.) *Beyond written computation* (pp. 30-39). Perth: MASTEC, Edith Cowan University.
- Ausabel, D.P. (1968). Facilitating meaningful verbal learning in the classroom. *Arithmetic Teacher*, 15, 126-132.
- Barry, J. (2002). The effects of metacognitive cues and probes on use of learners control features in an online lesson for elementary students. [on-line]. Available WWW:<http://www.pdkintl.org/edres/ddwind2.html>.
- Bell, A.W. (1993). Some experiments in diagnostic teaching. *Educational Studies in Mathematics*, 24(1), 115-137.
- Bell, J. (1987). *Doing your research project: A guide for first time researchers in education and social science*. Philadelphia: Open University Press.
- Biggs, J.B. & Moore, P. (1993). *The process of learning* (3<sup>rd</sup> ed.). Sydney: Prentice Hall.
- Booker, G., Bond, D. Sparrow, L. & Swan, P. (2004). *Teaching primary mathematics* (3<sup>rd</sup> ed.). Frenchs Forest, New South Wales: Pearson Education.
- Brown, A.L., Bransford, J.D., Ferrara, R.A., & Campione, J.C. (1983). Learning, remembering, and understanding. In J. Flavell & E. M. Markman (Eds.), *Handbook of child psychology: Cognitive development* (4th ed., pp. 515-629). New York: Wiley.
- Brown, A.L., & Palincsar, A.S. (1982). Inducing strategic learning from text by means of informed, self-control training. *Topics in Learning and Learning Disabilities*, 2, 1-17.

- Brown, A.L. & Palincsar, A.S. (1987). Reciprocal teaching of comprehension strategies: A natural history of one program for enhancing learning. In J. Borkowski & J.D. Day (Eds.), *Cognition in special education: Comparative approaches to retardation, learning disabilities, and giftedness*. Norwood, NJ: Ablex.
- Brown, A.L., & Palincsar, A.S. (1989). Guided, cooperative learning and individual knowledge acquisition. In L. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 393-451). Hillsdale, NJ: Lawrence Erlbaum Associates.
- Bruer, J. (1994). *The mind's journey from novice to expert* [on-line]. Available WWW: [www.jsmf.org/zarticles&pap/John/minds\\_journey.html](http://www.jsmf.org/zarticles&pap/John/minds_journey.html).
- Bruer, J. (1993). *Schools for thought*. Cambridge, MA: The MIT Press.
- Bruner, J.S. (1966). *Toward a theory of instruction*. Cambridge, MA: Harvard University Press.
- Burke, K., & Burke-Samide, B. (2004) Required changes in the classroom environment. *The Clearing House*, 77(6), 236.
- Burns, R. (1994). *Introduction to research methods*. Melbourne: Longman.
- Burton, L. *The constructivist classroom* [video]. (1993). Perth: MASTEC, Edith Cowan University.
- Chapin, S.H. & Johnson, A.J. (2000). *Math matters: Understanding the math you teach*. Sausalito, CA: Math Solutions Publications.
- Chase, W.G., & Simon, H.A. (1973). Perception in chess. *Cognitive Psychology*, 4, 55-81.
- Chi, M.T.H. & Glaser, R. (1981) Categorisation and representations of physics problems by experts and novices. *Cognition Science*, 5, 121-152.
- Cobb, P. (1990). A constructivist perspective on information-processing theories of mathematical activity. *International Journal of Educational Research*, 14(1), 67-92.
- Cobb, P., Boufi, A., McClain, K., & Whitenack, J. (1997). Reflective discourse and collective reflection. *Journal for Research in Mathematics Education*, 28(3), 258-277.
- Cole, M., & Wertsch, J.W. (2002). *Beyond the individual-social antimony in discussions of Piaget and Vygotsky* [on-line]. Available WWW: <http://www.massey.ac.nz/alog/virtual/colevyg.html>. [2002].
- Cohen, L., & Manion, L. (1985). *Research methods in education*. Sydney: Croom Helm.

- Cresswell, J. (1994). *Research design: Qualitative and quantitative approaches*. California: SAGE.
- Curriculum Council. (1998). *Curriculum Framework*. Perth: Curriculum Council.
- Curriculum Council. (2005). *Curriculum Framework Progress Maps: Mathematics*. Perth: Curriculum Council.
- Curriculum Programs Branch. (1989). *Learning Mathematics: Pre-primary to Stage Seven Mathematics Syllabus*. Perth: WA Ministry of Education.
- Daley, B.J., (1999) Novice to expert: An exploration of how professionals learn. *Adult Education Quarterly*, 49(4), 133–47.
- Dart, B., Burnett, P., Purdie, N., Boulton-Lewis, G., Campbell, J., & Smith, D. (2000). Students' conceptions of learning, the classroom environment, and approaches to learning. *The Journal of Educational Research*, 93(4), 262-270.
- Dienes, Z.P. (1967). *Building up mathematics*. London: Hutchinson.
- Department of Education and Training. (2005). *Outcomes and Standards Framework: Mathematics*. Perth: Department of Education and Training.
- Dole, S., (2004). Rethinking percent instruction in the middle grades. In A. McIntosh & L. Sparrow (Eds.) *Beyond written computation* (pp. 137-147). Perth: MASTEC, Edith Cowan University.
- Duffin, J. (1991). Written Algorithms. *Mathematics in Schools*, 20(4), 41-43.
- Dunn, R., Krinsky, J., Murray, J.B. & Quinn, P.J. (1986). The effects of school lighting on achievement and behaviour. *The Education Digest*, 51(6), 58.
- EDU6195 Advanced Seminar; Gahandra Verma [Computer Software]. (2003). Perth: Edith Cowan University.
- Ertmer, P. & Newby, T. (1996). The expert learner: Strategic, self-regulated and reflective. *Instructional Science*, 24, 1-23.
- Fuchs, L.S., Fuchs, D., & Prentice, K. (2003). Enhancing third-grade students' mathematical problem solving with self-regulated learning strategies. *Journal of Educational Psychology*, 95(2), 306-315.
- Fuller, R. (2000). *The study of learning*. [Brochure]. Perth, Western Australia: Edith Cowan University.
- Gagne, R.M., & White, R.T. (1978). Memory structures and learning outcomes. *Review of Educational Research*, 48, 187-222.
- Garofalo, J., & Lester, F.K. (1985). Metacognition, cognitive monitoring, and mathematical performance. *Journal for Research in Mathematics Education*, 16(3), 163-176.

- Gerston, R. (1999). Rethinking arithmetic instruction for students with mathematical disabilities. *Journal for Special Education, 44*, 18-28.
- Ginsburg, H., & Opper, S. (1969). *Piaget's theory of intellectual development: An introduction*. Englewood Cliffs, NJ: Prentice Hall.
- Glaser, R. & Chi, M. (1988). Overview. In M. Chi, R. Glaser & M. J. Farr, (Eds), *The nature of expertise* (pp. xv-xxviii). Hillsdale, NJ: Lawrence Erlbaum.
- Good, T.L., & Brophy, J.E. (1997). *Looking in classrooms*. (7<sup>th</sup> Ed). New York: Longman.
- Gravemeijer, K., van Galen, F., Boswinkel, N., van den Heuvel-Panhuizen, M. (2004). Semi-informal routines as alternatives for standard algorithm in the primary school. In A. McIntosh & L. Sparrow (Eds.) *Beyond written computation* (pp.126-136). Perth: MASTEC, Edith Cowan University.
- Herrington, A.J. (1990). Strategies for developing mathematical understanding. In K. Milton & H. McCann (Eds.), *Mathematical turning points: Strategies for the 1990s* (pp. 325-340). Hobart: AAMT.
- Herrington, A.J. (1992). *Student beliefs and strategies for learning mathematics*. Unpublished PhD Thesis, University of Western Australia.
- Hughes, J. (1990) *The philosophy of social research*. New York: Longman.
- Johnson, B., & Christensen, L., (2004). *Educational research: Quantitative, qualitative and mixed approaches*. Boston: Pearson.
- King, A. (1992). Facilitating elaborated learning through guided student-generated questioning. *Educational Psychologist, 27*(1), 111-126.
- Kramaski, B., Mevarech, Z.R., & Arami, M. (2002). The effects of metacognitive instruction on solving mathematical authentic tasks. *Educational Studies in Mathematics, 49*(2), 225-250.
- Kramaski, B., & Mevarech, Z.R. (2003) Enhancing mathematical reasoning in the classroom: Effects of co-operative learning and metacognitive training. *American Educational Research Journal, 40*, 281-310.
- Laydor, D. (1993). *New strategies in social research*. Cambridge: Polity Press.
- Lin, X.D., & Lehman, J. (1999). Supporting learning of variable control in a computer-based biology environment: Effects of prompting college students to reflect on their own thinking. *Journal of Research in Science Teaching, 36*(7), 1-22.
- Losq, C.S. (2005). Number concepts and special needs students: The power of ten-frame tiles. *Teaching Children Mathematics, 11*(6), 310-315.

- Mandler, G. (1989). Affect and learning: Causes and consequences of emotional interactions. In D.B. McLeod & V.M. Adams (Eds), *Affect and mathematical problem solving: A new perspective* (pp. 3-19). New York: Springer-Verlag.
- Markovits, Z., Hershlowitz, R. Bruckheimer, M. (1989). Research into practice. *Arithmetic Teacher*, 36(6), 53.
- Marshall, C., & Rossman, G. B. (1995). *Designing qualitative research*. Thousand Oaks, CA: Sage.
- Maykut, P., & Morehouse, R. (1994). *Beginning qualitative research: A philosophic and practical guide*. London: The Falmer Press.
- McCrinkle, A. & Christensen, C. (1995). The impact of learning journals on metacognitive and cognitive process and learning performances. *Learning and Instruction*, 5, 167-185.
- McKeachie, W.J., Pintrich, P., Lin, Y.G. & Smith, D. (1986). *Teaching and learning in the college classroom*. University of Michigan: National Center for Research to Improve Post-secondary Teaching and Learning.
- McIntosh, A., Reys, B., Reys, R., Bana, J., & Farrell, B. (1997). *Number sense in school mathematics: Student performance in four countries*. Perth: MASTEC, Edith Cowan University.
- McIntosh, A., (2004). Where we are today. In A. McIntosh & L. Sparrow (Eds.) *Beyond written computation* (pp. 3-14). Perth: MASTEC, Edith Cowan University.
- Meichenbaum, D. (1985). Teaching thinking: A cognitive behavioural perspective. In S.F. Chipman, J.W. Segal & R. Glaser (Eds.), *Thinking and learning skills. Volume 2: Research and open questions* (pp. 407-426). Hillsdale, NJ: LEA.
- McLeod, D.B. (1990). Information-processing theories and mathematics learning: The role of effect. *The International Journal of Educational Research*, 14(1), 13-29.
- Mulligan, J. (2004). Key aspects of early number learning. In A. McIntosh & L. Sparrow (Eds.) *Beyond written computation* (pp. 17-29). Perth: MASTEC, Edith Cowan University.
- Murphy, E. (1997). *Constructivist learning theory* [on-line]. Available WWW: <http://www.stemnet.nf.ca/~elmurphy/emurphy/cle2b.html>. [2002].
- Naglieri, J. & Johnson, D. (2000). Effectiveness of a cognitive strategy intervention in improving arithmetic computation based on the PASS theory. *Journal of Learning Disabilities* 33(6), 591-597.
- Nicholl, P.M. (1998). *Vygotsky* [on-line]. Available WWW: <http://massey.ac.nz/~alock/virtual/trishvyg.html>.

- Norman, D.A. (1981). Twelve issues for cognitive science. In D.A. Norman (Ed.), *Perspectives on cognitive science* (pp. 265-295). Norwood, NJ: Ablex.
- Patton M. (1990). *Qualitative evaluation and research methods* (2<sup>nd</sup> ed.). Newberry Park, CA: Sage Publications.
- Piaget, J. (1962). The stages of the intellectual development of the child. *Bulletin of the Menninger Clinic*, 26, 120-128.
- Pintrich, P., Marx, R., & Boyle, R. (1993). Beyond cold conceptual change: The role of motivational beliefs and classroom contextual factors in the process of conceptual change. *Review of Educational Research*, 63, 167-185.
- Polya, G. (1957). *How to solve it*. Princeton, NJ: Princeton University Press.
- Purdie, N., Hattie, J. & Douglas, G. (1996). Student conceptions of learning and their use of self regulated learning strategies: A cross cultural comparison. *Journal of Educational Psychology*, 88(1), 87-100.
- Schoenfeld, A. (1992). Learning to think mathematically: Problem solving, metacognition and sense making in mathematics. In D. Grouws (Ed.), *Handbook for research on mathematics teaching and learning*. New York: Macmillan.
- Silver, E.A. (1987). Foundations of cognitive theory and research for mathematics in problem-solving instruction. In A.H. Schoenfeld (Ed.), *Cognitive science and mathematics education* (pp. 33-60). Hillsdale, NJ: LEA.
- Skemp, R.R. (1976). Relational understanding and instrumental understanding. *Mathematics Teaching*, 77, 20-28.
- Slavin, R.E. (1995) *Research on cooperative learning and achievement: What we know, what we need to know [on-line]*. Available WWW: <http://www.successsforall.com/resouce/research/cooplearn.html>.
- Sowder, J.T. (1990). Mental computation and number sense. *The Arithmetic Teacher*, 37(7), 1.
- Sparrow, L. & McIntosh, A. (2004). Developing number sense in classrooms. In A. McIntosh & L. Sparrow (Eds.) *Beyond written computation* (pp. 150-159). Perth: MASTEC, Edith Cowan University.
- Sparrow, L. & Swan, P. (2004). Techno-ignorant, techno-dependant, or techno-literate? A case for sensible calculator use. In A. McIntosh & L. Sparrow (Eds.) *Beyond written computation* (pp. 53-63). Perth: MASTEC, Edith Cowan University.
- Strauss, A. (1987). *Qualitative analysis for social scientists*. Cambridge, New York: Cambridge University Press.
- Swan, P. (1996). *Kids calculators and classrooms: Using calculators in the primary school*. Perth: A-Z Type.

- Thorndike, E.L. (1924). *The psychology of arithmetic*. Macmillan: New York. In J.K. Bidwell & R.G. Glason (Eds.), (1970), *Readings in the history of mathematics education* (pp. 463-477). Washington, DC: NCTM.
- Thornton, C.A., & Tucker S.C., (1989) Lesson Planning: The key to developing number sense. *Arithmetic Teacher*, 36(6), 18-21.
- Trafton, P. & Thiessen, D. (2004). Linking mental and written computation via extended work with invented strategies. In A. McIntosh & L. Sparrow (Eds.) *Beyond written computation* (pp. 113-125). Perth: MASTEC, Edith Cowan University.
- von Glasersfeld, E. (1990). An exposition of constructivism: Why some like it radical. In R.B. Davis, C.A. Maher & N. Noddings (Eds), *Constructivist views on the teaching and learning of mathematics* (pp.19-29). Reston, VA: NCTM.
- von Glasersfeld, E. (1997). Constructivist learning theory [online]. Available WWW: <http://www.cdli.ca/~elmurphy/emurphy/cle2b.html> [2005].
- von Glasersfeld, E. (1998). *Ernst von Glasersfeld's answers* [on-line]. Available WWW: <http://www.oikos.org/answersfeb.html> [2005].
- Good, T.L., & Brophy, J.E. (1997). *Looking in classrooms*. (7<sup>th</sup> Ed). New York: Longman.
- Van Rossum, E.J. & Schenk, S. (1984). The relationship between learning conception, study strategy and learning outcome. *British Journal of Educational Psychology*, 54, 73-88.
- Vygotsky, L.S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge: Harvard University Press.
- Weinstein, C.E. & Van Mater Stone, G. (1993). Broadening our conception of general education: The self-regulated learner. *New directions for community college* (pp.31-39). San Francisco: Jersey.
- Weirsmas, W., & Jurs. S.G. (2005). *Research methods in education: An introduction*. Boston: Pearson/Allyn Bacon.
- Whitenack, J., Knipping, N., Noringer & S., Underwood, G. (2004). Facilitating children's conceptions of tens and ones: The classroom teacher's important role. In A. McIntosh & L. Sparrow (Eds.) *Beyond written computation* (pp. 40-50). Perth: MASTEC, Edith Cowan University.
- Yang, D.C. & Reys, R.E. (2000) One fraction problem, many solution paths. *Mathematics Teaching in the Middle School*, 7(2), 164.
- Zimmerman, B.J. (1998) Self-regulated learning and academic achievement: An overview. *Educational Psychologist*, 25(1), 3-17.

## **APPENDIX A: NUMBER SENSE TEST**

### **Protocol for Number Sense Test (McIntosh et al., 1997)**

#### **1. Introduce yourself to the class:**

Say, I am..... from Edith Cowan University. This is a test that was used in an international study [changed original wording which said this is the international study etc.]

#### **2. Personal details:**

Have students clear their desk and get a pen /pencil ready.

Give out test papers face down, then ask students to turn the paper over and have them write in their names and other details as required.

#### **3. Preparation for test:**

Tell students: “Today I want you to do the maths problems mentally. That is, do all the calculations (working) in your head. Only write the answer or circle the right answer. Don’t do any other writing. In many questions you will be asked to estimate rather than calculate the answer exactly. Be sure to follow those directions. I will read each question while you follow me. Then I’ll give you half a minute – 30 seconds, to do it, before asking you to go on the next question.

#### **4. Practice questions:**

Put OHT of cover page on OHP and say: “The left side of the page has the questions and the right side is where you show your answers. I now want you to try the first practice question. I’ll read it for you while you follow on your sheet, and when I finish reading, you’ll have half a minute – 30 seconds – to do it”. Read the question out loud. Allow half a minute. Indicate and justify the correct answer and the need to circle the matching letter rather than the whole answer.

Say: “Now we’ll try the second practice question”. Read the question out loud, allow half a minute, then indicate and explain the correct response and how this was to be recorded.



Say “There are 35 questions in this test and they are all set out like these two. I’ll read each question and then allow half a minute – 30 seconds. This should be plenty of time for each question. If you make a mistake cross it out and try again. Don’t forget to only write the answer – no other writing is allowed. Are there any questions about the test?” Answer as appropriate.

5. The test:

Say: “Now we are ready to start. Turn to the next page. Question 1 says...”Read the question out loud, making sure to emphasise underscored words and allow 30 seconds. Then say Question 2 ...”; and so on until the test is complete.


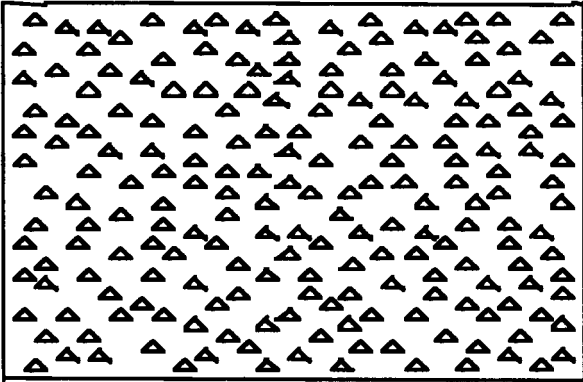
Practice Questions:

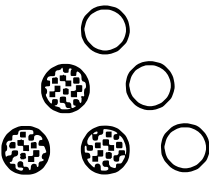
1. <u>Without counting exactly</u> , about how many children are there in your class? (Circle the nearest answer.)	A. 3 B. 30 C. 300 D. 3000
2. What number goes in the box to make this sentence true?  30 + <input type="text"/> = 50	<hr/>


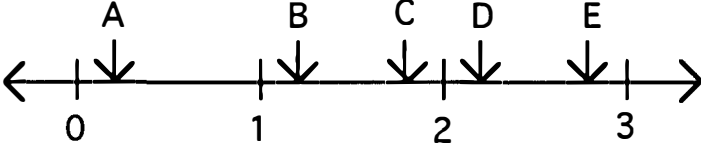
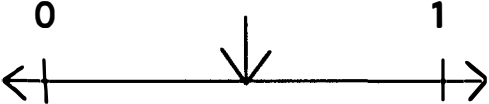
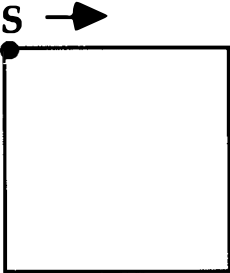
## NUMBER SENSE GROUP TEST

### QUESTION

### ANSWER

<p>1. <u>About</u> how many days have you lived? (Circle the nearest answer.)</p>	<p>A. 300 B. 3000 C. 30 000 D. 300 000</p>
<p>2. <u>About</u> how much of this box is shaded? Give your answer as a <u>fraction</u>.</p> <div style="text-align: center; margin: 10px 0;">  </div>	<p>_____</p>
<p>3. <u>About</u> how many triangles are there here? (Circle the nearest answer.)</p> <div style="text-align: center; margin: 10px 0;">  </div>	<p>A. 20 B. 50 C. 100 D. 200 E. 500</p>
<p>4. The digits are 0, 1, 2, 3, 4, 5, 6, 7, 8, 9.</p> <p style="margin-left: 40px;">Put one digit in each box so that the answer will be as big as possible.</p>	<p>4 <span style="border: 1px solid black; display: inline-block; width: 20px; height: 20px; vertical-align: middle;"></span> <span style="border: 1px solid black; display: inline-block; width: 20px; height: 20px; vertical-align: middle;"></span> - 231 = ?</p>

<p>5. Put one digit in each box so that the answer will be as big as possible.</p>	$431 - 2\boxed{\phantom{0}}\boxed{\phantom{0}} = ?$													
<p>6. Here are five digits: 2, 6, 3, 5, 1. Arrange <u>all</u> these digits to make the smallest number possible.</p>	<hr/>													
<p>7. Here are five digits, 2, 6, 3, 5, 1. Arrange them to make the number nearest to 20 000.</p>	<hr/>													
<p>8. The police department is counting the number of cars on a certain highway. The counting meter now reads:</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td style="padding: 2px 10px;">4</td> <td style="padding: 2px 10px;">7</td> <td style="padding: 2px 10px;">3</td> <td style="padding: 2px 10px;">9</td> <td style="padding: 2px 10px;">9</td> </tr> </table> <p>What will it read after one more car passes by?</p>	4	7	3	9	9	<table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> <td style="width: 20px; height: 20px;"></td> </tr> </table>								
4	7	3	9	9										
<p>9. Circle the fraction which shows how much has been shaded.</p> <div style="text-align: center;">  </div>	<p>A. <math>\frac{2}{4}</math></p> <p>B. <math>\frac{2}{6}</math></p> <p>C. <math>\frac{4}{6}</math></p> <p>D. <math>\frac{4}{2}</math></p>													
<p>10. The farmer has stored all his apples in 80 boxes with 40 apples in each box. He now needs to repack them all into 40 new boxes.</p> <p>How many apples will there be in each new box?</p>	<p>A. 2</p> <p>B. 40</p> <p>C. 80</p> <p>D. 120</p>													
<p>11. For a long time Jane has been putting only 10 cent coins in her piggy bank. Last night she opened it and counted her money. She had \$46.70. How many 10 cent coins were in the bank?</p>	<hr/>													
<p>12. Place the numbers 0.1 and 0.8 in their correct positions on this number line:</p>	<table style="margin-left: auto; margin-right: auto;"> <tr> <td style="text-align: center;">0</td> <td style="text-align: center;">1</td> </tr> <tr> <td style="text-align: center;">← </td> <td style="text-align: center;"> →</td> </tr> </table>	0	1	←	→									
0	1													
←	→													

<p>13. Place the numbers <math>\frac{1}{10}</math> and <math>\frac{4}{5}</math> in their correct positions on this number line:</p>	
<p>14. Which letter on the number line below best represents 2.19?</p> 	<p>_____</p>
<p>15. Circle the fraction which represents the largest amount:</p>	<p>A. <math>\frac{5}{6}</math>      B. <math>\frac{5}{7}</math></p> <p>C. <math>\frac{5}{8}</math>      D. <math>\frac{5}{9}</math></p>
<p>16. <u>Without calculating the exact answer</u>, circle the best estimate for:</p> <p style="text-align: center;">29 x 0.98</p>	<p>A. more than 29</p> <p>B. less than 29</p> <p>C. impossible to tell without working it out</p>
<p>17. <u>Estimate the decimal</u> shown by the arrow on the number line:</p> 	<p>_____</p>
<p>18. You are going to walk once around a square-shaped field. You start at the corner marked S and move in the direction shown by the arrow. Mark with an X where you will be after <math>\frac{1}{3}</math> of your walk.</p>	
<p>19. <u>Without calculating the exact answer</u>, circle the largest product.</p>	<p>A. 18 x 17</p> <p>B. 16 x 18</p> <p>C. 17 x 19</p>

<p>20. Which is greater?</p>	<p>A. <math>29 \div 0.8</math>  B. <math>29 \times 0.8</math>  C. <math>29 + 0.8</math>  D. Impossible to tell without calculating</p>
<p>21. When a 3-digit number is added to a 3-digit number the result is:</p>	<p>A. always a 3-digit number  B. always a 4-digit number  C. always a 5-digit number  D. either a 3, 4 or 5-digit number  E. either a 3 or 4 digit number</p>
<p>22. <u>Without calculating</u>, circle the expression which represents the larger amount.</p>	<p>A. <math>145 \times 4</math>  B. <math>144 + 146 + 148 + 150</math></p>
<p>23. <u>Without calculating the exact answers</u>, circle the best estimate for:</p> <p style="text-align: center;"><math>18 \times 19</math></p>	<p>A. 290  B. 390  C. 490</p>
<p>24. Ten bottles of juice cost \$7.95 at one store. I can get 5 bottles for \$4.15 at a second store. Where is the juice cheaper - at the first or second store?</p>	<p>A. First store  B. Second store</p> <p>Tell how you decided:</p> <hr/> <hr/>

<p>25. Which two numbers multiplied together give an answer closest to the target number?</p> <p style="text-align: center;">4      18      50      37</p> <p>Target Number <span style="border: 1px solid black; padding: 2px 10px;">75</span></p>	<p>_____ and _____</p>
<p>26. Which two numbers multiplied together give an answer closest to the target number?</p> <p style="text-align: center;">4      18      50      37</p> <p>Target Number <span style="border: 1px solid black; padding: 2px 10px;">1000</span></p>	<p>_____ and _____</p>
<p>27. <math>16 \times 0 = \square</math></p> <p>The number in the box....</p>	<p>A. ...must be 16</p> <p>B. ...must be 160</p> <p>C. ...must be 0</p> <p>D. ...could be any number</p>
<p>28. <math>15 \times \square = 15</math></p> <p>The number in the box....</p>	<p>A. ...must be 0</p> <p>B. ...must be <math>\frac{1}{5}</math></p> <p>C. ...must be 1</p> <p>D. ...must be 15</p> <p>E. ...could be any number</p>
<p>29. <math>\frac{3}{4}</math> is a fraction between <math>\frac{1}{2}</math> and 1.</p> <p>Name another fraction between <math>\frac{1}{2}</math> and 1.</p>	<p>_____</p>
<p>30. <u>Without calculating the exact answer</u>, circle the best estimate for:</p> <p style="text-align: center;"><math>29 \div 0.8</math></p>	<p>A. less than 29</p> <p>B. equal to 29</p> <p>C. greater than 29</p> <p>D. impossible to tell without calculating</p>

<p>31. Put two of the numbers  <b>4, 9, 12</b>  in the boxes to make a fraction as close as possible to <math>\frac{1}{2}</math>.</p>	<div style="text-align: center;"> <input style="width: 40px; height: 30px; border: 1px solid black;" type="text"/>  <hr style="width: 100%; border: 0.5px solid black;"/> <input style="width: 40px; height: 30px; border: 1px solid black;" type="text"/> </div>
<p>32. If I have \$378 in my savings account and withdraw all my money, how many 10-dollar notes would the bank be willing to give me?</p>	<hr style="width: 100%; border: 0.5px solid black;"/>
<p>33. Mary had \$426 and spent 0.9 of it on clothes. <u>Without calculating the exact answer</u>, circle the best estimate for how much she spent.</p>	<p>A. slightly less than \$426  B. much less than \$426  C. slightly more than \$426  D. impossible to tell without calculating</p>
<p>34. Jim bought 3 sleeping bags at \$98 each. How could he work out how much he spent?    (Circle the correct answer.)</p>	<p>A. 3 lots of \$100, take \$1  B. 3 lots of \$100, take \$2  C. 3 lots of \$100, take \$3  D. 3 lots of \$100, take \$6</p>
<p>35. <u>Without calculating the exact answer</u>, circle the best estimate for:    45 x 105</p>	<p>A. 4000  B. 4600  C. 5200</p>

## APPENDIX B: TEST RESULTS

Table 2. Raw Data Test Result for Pre-Tests and Post-Tests.

<b>Name</b>	<b>Pre-Test</b>	<b>Post-Test</b>
Karen	19	23
Ann	28	31
Jane	18	21
Peter	18	27
Joshua	27	30
Daisy	25	31
John	23	26
Delia	16	19
Jason	30	32
Russel	17	26
Tony	22	18
David	23	33
Catherine	22	26
Debbie	13	18
Anthony	21	21
Margaret	25	30
Sharon	16	18
Francis	16	22
Diane	26	29
Christopher	30	30
Frank	11	12
Simone	16	21
Jill	20	13
Sarah	16	22
Bill	24	24
Joseph	26	28
Elle	28	27
Leah	24	21
Toni	27	26
Phillipa	6	12
Mary	15	16
Jonathan	12	10
<b>AVERAGE</b>	<b>20.63</b>	<b>23.22</b>



## APPENDIX C: REFLECTIVE PROMPT

### **Planning after 10 minutes**

**Complete this on your own. Remember - If you need help it is important that you go and find the answer to your problem.**

What is the goal of this lesson?.....

How can I do this activity? .....

What am I good at that will help me?.....

Do I have to really concentrate? Yes/No

Do I enjoy this activity? Yes/No

Do I have every thing that I need? Yes/No

### **Mid-Action Reflection after 30 minutes**

Is the way I chose to solve this work, working? Yes/No

Do I understand what I am doing? Yes/No

Am I making progress towards my goal? Yes/No

Is this activity interesting? Yes/No

Do I feel confident? Yes/No

Have I got everything I need? Yes/No

Am I giving myself enough time? Yes/No

### **Notes about my mathematics learning (use extra paper if needed).**

(What I would like to change, what I don't understand, what I am amazed that I do understand)

.....

.....

.....

.....

.....

.....

## APPENDIX D: ADAPTED REFLECTIVE PROMPT

Week beginning ..... **Name:** \_\_\_\_\_

### Monday

#### **Planning (complete after 10 minutes)**

What is the goal of this lesson? .....

How can I do this activity.....

.....

What am I good at that will help me?.....

.....

Do I have to really concentrate? Yes/No

Do I enjoy this activity? Yes/No

Do I have every thing that I need? Yes/No

#### **Mid-Action Reflection**

Is the way I chose to solve this work, working? Yes/No

Do I understand what I am doing? Yes/No

Am I making progress towards my goal? Yes/No

Is this activity interesting? Yes/No

Do I feel confident? Yes/No

Have I got everything I need? Yes/No

Am I giving myself enough time? Yes/No

#### **Notes about my mathematics learning (use space on the back if needed)**

.....

.....

.....

.....

**Wednesday**

**Planning (complete this after 10minutes)**

What is the goal of this lesson?.....  
.....  
.....

How can I do this activity.....  
.....

What am I good at that will help me?.....  
.....

Do I have to really concentrate? Yes/No

Do I enjoy this activity? Yes/No

Do I have every thing that I need? Yes/No

**Mid-Action Reflection**

Is the way I chose to solve this work, working? Yes/No

Do I understand what I am doing? Yes/No

Am I making progress towards my goal? Yes/No

Is this activity interesting? Yes/No

Do I feel confident? Yes/No

Have I got everything I need? Yes/No

Am I giving myself enough time? Yes/No

**Notes about my mathematics learning (use space on the back if needed)**

.....  
.....  
.....  
.....

## APPENDIX E: TEACHER'S REFLECTION SHEET

### **Reflective Class Discussion. Last 5 minutes of the lesson**

**(Discuss the following with the students. Rotate the questions from the selection below. Try to model some expert approaches to learning)**

How well did you do in this task?

What did you do when your method of working didn't work?

How could you improve your work?

Did you achieve your goal?

What did you learn?

What new goals do you have now?

Did you have to put in a lot of effort?

Did you stay motivated?

How do you feel about your work?

Did you enjoy it?

Did you have any problems?

Did you have every thing that you needed?

## APPENDIX F: PERMISSION LETTERS

### Letter to Principal

Dear Principal

#### **Re: Request for volunteers to participate in M.Ed study**

I am an experienced teacher and an M.ED student at Edith Cowan University researching mathematics education. I am currently seeking a Year 6 class in the Perth Metropolitan area to participate in some research, which is focusing on supporting children as they work in their mathematics class. The title of my thesis is: *The effects of using an expert learning process on Year 6 mathematics learning*. The ECU Human Research Ethics Committee has approved this research study.

I plan to incorporate a guide (reflective prompt) designed to encourage children to reflect on their mathematical thinking. The children will refer to this in their normal mathematics lessons, and discussions will take place in order to support this process. As this study takes place in their mathematics lessons no interruptions to their normal program will occur. Instead it should be enhanced. I will be spending time with the class and observing any effects that may take place. For the first two weeks I hope to attend most of the mathematics classes and then I will attend two mornings per week. I plan to conduct short interviews with the children throughout the exploratory study and test the children on their number sense ability at the beginning and end of the study. I will also interview the teacher and ask if he/she could complete a diary detailing any effects on the children's learning that have been observed. The research will take place over two terms and the results may be published, as they will form part of my thesis. In order to protect students' privacy, neither the students nor the school will be directly identified in any publication. Pseudonyms will be used to protect each student's identity. Tape-recorded interviews will be erased following transcription and all information will be stored securely at the university. Parents may withdraw their child from participation, at any stage in the process if they wish to do so. I would like to call you next week, to see if your school would be interested in participation in this study.

Please do not hesitate to call my supervisor, ....., if you have any queries. Either of us would be happy to discuss with you any issues that you may have. I have enclosed copies of the parental information and informed consent form, for your perusal.

Yours faithfully,

### **Letter to Teacher**

Dear Teacher

#### **Re: Request for volunteers to participate in M.Ed study**

I am an experienced teacher and an M.Ed student at Edith Cowan University researching mathematics education. I am currently seeking a Year 6 class teacher in the Perth Metropolitan area to participate in some research, which is focusing on supporting children as they work in their mathematics class. I have already written to your Principal and he has given approval for the study to be conducted in your school and the ECU Human Research Ethics Committee has also approved this research study. The title of my thesis is: *The effects of using an expert learning process on Year 6 mathematics learning*.

Initially I hope to hold a consultation session with you, lasting a couple of hours in total, in order to discuss the project and answer any questions that you may have. Once you feel comfortable with the implementation of the study, a guide (reflective prompt) designed to encourage children to reflect on their mathematical thinking, will be incorporated into your class's normal mathematics lessons. Discussions with the children will take place in order to support this process. As this study takes place in the mathematics lessons no interruptions to your normal program will occur. Instead it should be enhanced, as I should be able to support you working with the children. I plan to spend time with the class and observe any effects that may take place. For the first two weeks I hope to attend most of the mathematics classes and then I will attend two mornings per week. I plan to conduct short interviews with the children throughout the exploratory study and test the children on their number sense ability at the beginning and end of the study. I also hope to

conduct a short interview with yourself, and ask if you could complete a diary detailing, briefly, any effects on the children's learning that have been observed.

The research will take place over two terms and the results may be published, as they will form part of my thesis. In order to protect students' and teacher privacy, neither the students, teacher or the school will be directly identified in any publication. Pseudonyms will be used to protect each student's identity. Tape-recorded interviews will be erased following transcription and all information will be stored securely at the university. Parents may withdraw their child from participation, at any stage in the process if they wish to do so. I would like to call you next week, to see if you would be interested in participation in this study. This participation is purely voluntary and you are free to withdraw your consent at any time, including the withdrawal of information or material that has been collected.

Please do not hesitate to call my supervisor, .....if you have any queries. Either of us would be happy to discuss with you any issues that you may have, If you have any concerns or complaints about the research project and wish to talk to an independent person, you may contact..... I have enclosed copies of the parental information and informed consent form, for your use.

Yours faithfully,

I, \_\_\_\_\_ (name of Teacher),

hereby consent to participate in a study designed to encourage students in their mathematical thinking by ....I have been provided with information about the study and have been given the opportunity to ask questions. I am aware that I may contact the researcher at any time. I understand that I will be involved in supporting the implementation of an expert learning process incorporated into the normal Year 6 mathematics classroom. During this process I will be interviewed and will complete a diary. I agree that the research data gathered for this study may be published, provided that neither the students nor the schools are identified. I understand that I may withdraw at any stage if I wish to do so.

---

2004

(Signature of Teacher)

(Date)

## Letter to Parents

Dear Parent/s

I am an experienced teacher and an M.Ed. student at Edith Cowan University researching mathematics education. I am seeking parental permission for your child to be involved on a research study which is being undertaken as part of the requirements for my M.Ed degree. The Principal and your child's class teacher have both approved the conduct of this study. The ECU Human Research Ethics Committee has also approved the research study. The study is planned to be incorporated into your child's normal mathematics class. The title of my thesis is: *The effects of using an expert learning process on Year 6 mathematics learning.*

I plan to incorporate a guide (reflective prompt) designed to encourage students to reflect on their mathematical thinking. The students will refer to this guide in their normal mathematics lessons, and discussions will take place in order to support this process. I will be spending time in the class over two terms and observing any effects that may take place. I plan to conduct short interviews with the children throughout the exploratory study and these will be audio taped. The children will not be disrupted in any way, as the normal mathematics program will continue and it should be enhanced with the reflective prompt. They will also receive the obvious benefits of working with an extra teacher in the classroom.

The results of the study will form part of my thesis. In order to protect your child's privacy, neither the students nor the schools will be identified in any publication and pseudonyms will be used to protect each student's identity. Tape-recorded interviews will be erased following transcription and all information will be stored securely at the university. You may withdraw your child from participation, at any stage in the process if you wish to do so.

If you have any concerns about the project or would prefer to speak to an independent person please contact ..... Naturally, I would be happy to discuss with you and/or your child any issues that arise before, during and/or after the study..... I would like to mention that participation is purely voluntary and that you are free to withdraw your consent to further involvement in the research project



at any time. This also includes the right to withdraw information or material that has already been collected. If you agree to your child's participation in a session, please sign the attached consent form and return it to your school office.

Yours faithfully,

To: the School Office, \_\_\_\_\_ School,

I, \_\_\_\_\_ (name of Parent/Guardian), hereby give consent for my son/ daughter \_\_\_\_\_ to participate in a study designed to encourage students in their mathematical thinking as part of her studies at Edith Cowan University. I have been provided with information about the study and have been given the opportunity to ask questions. I am aware that I may contact the researcher at any time. I understand that my child will be involved in an expert learning process incorporated into the normal Year 6 mathematics classroom. During this process my child will be observed completing mathematical tasks and the reflective prompt and that my child will be interviewed. I agree that the research data gathered for this study may be published provided that neither the students nor the schools are identified. I understand that I may withdraw my child at any stage if I wish to do so.

My child is in class \_\_\_\_\_

\_\_\_\_\_  
(Signature of Parent / Guardian)

\_\_\_\_\_  
(Date)

## **APPENDIX G: STUDENT PRE-STUDY INTERVIEW**

### **SCHEDULE**

All interviews completed between 28th June 2004 and 9th July 2004 in school time between 9.00am and 3.00pm.

Thankyou for being willing to take part in this interview.

I want you to be relaxed and just say what you really think. Remember anything you say is completely confidential.

1. What is your favourite subject at school?
2. What do you think about the subject mathematics?
3. Do you find it easy, hard or a mixture of the two?
  - a) What do you do when you find things difficult in maths?
  - b) Why do you think some children are good at maths whereas others are not?
4. How does the teacher know you have learnt something in mathematics?
5. How do you know when you have learned something in mathematics class?
6. What do you actually do in order to learn something in the mathematics class?
7. What do you like your teacher to do to help you learn?
8. When you learn something at home that you haven't done at school, do you learn in the same way that you learn at school?
9. In mathematics classes what different types of planning do you do?
10. What do you think about working in groups in mathematics?  
Does it make the learning easier. (If yes) - why/how?  
Is it distracting? (if yes) –why/how
11. Do you check your mathematics work?
- 12 Do you ever think about how you are doing in your mathematics work?  
(if yes)- Do you then change things after thinking about them?

Thank you for your help today.

[Questions adapted from Fuller (2000).]

## APPENDIX H: SAMPLE OF PRE-STUDY STUDENT

### INTERVIEW TRANSCRIPTS

#### Pre-study interview with Debbie

Thankyou for being willing to take part in this interview.

I want you to be relaxed and just say what you really think. Remember anything you say is completely confidential.

1. What is your favourite subject at school?

*Art.*

2. What do you think about the subject mathematics?

*Fun - some areas are but some areas pretty boring.*

3. Do you find mathematics easy, hard or a mixture of the two?

*Mixture of the two.*

a) What do you do when you find things difficult in maths?

*Go back and read things to help you. Ask for help how to understand what it means.*

b) Why do you think some children are good at maths whereas others are not?

*Some practice and listen.*

4. How does the teacher know you have learnt something in mathematics?

*Shows when she's teaching you and reviewing it. Putting up your hand.*

5. How do you know when you have learned something in mathematics class?

*You would understand it and able to find the answer.*

6. What do you actually do in order to learn something in the maths class?

*I would listen to what is expected of me If I wanted to learn it and if I didn't understand I would ask.*

7. What do you like your teacher to do to help you learn?

*I don't want the answers or a hint.*

8. When you learn something at home that you haven't done at school, do you learn in the same way that you learn at school?

*Not really, my Dad comes from Scotland he works it out a different way. He teaches this way, and I work it out that way because I was taught first.*

9. In mathematics classes what different types of planning do you do?

*Set things out in steps, take things through slowly, write it down, plan to work it out.*

10. What do you think about working in groups in mathematics? Does it make the learning easier?

*Sometimes it can be frustrating cos they expect a lot of me; they keep bugging you.*

11. Do you check your mathematics work?

*It is important a lot go back to check it if I make a couple of silly mistakes.*

12 Do you ever think about how you are doing in your mathematics work?

*Yesterday I was quite anxious, I like maths.*

Do you then change things after thinking about them?

*If its easier to understand then yes.*

Thank you for your help today.

### **Pre-study interview with Catherine**

Thank you for being willing to take part in this interview.

I want you to be relaxed and just say what you really think. Remember anything you say is completely confidential.

1. What is your favourite subject at school?

*Computing and sparks [gifted pupil program].*

2. What do you think about the subject mathematics?

*I don't really like it.*

3. Do you find mathematics easy, hard or a mixture of the two?

*Mixture of the two.*

a) What do you do when you find things difficult in maths?

*Try and work it step by step.*

b) Why do you think some children are good at maths whereas others are not?

*Children don't really like maths, they can't listen.*

4. How does the teacher know you have learnt something in mathematics?

*She tests you.*

5. How do you know when you have learned something in mathematics class?

*When I can remember it.*

6. What do you actually do in order to learn something in the maths class?

*When she's talking I write down stuff.*

7. What do you like your teacher to do to help you learn?

*Everything's fine.*

8. When you learn something at home that you haven't done at school, do you learn in the same way that you learn at school?

*No I come from Singapore, we do maths different there - we do long division.*

9. In mathematics classes what different types of planning do you do?  
*I don't know.*

10. What do you think about working in groups in mathematics?  
*I don't like working in groups cos then I cant work at my own speed.*

11. Do you check your mathematics work?  
*Yes.*  
Why is it important?  
*Cos like if I make a mistake I can just rub it out.*

12 Do you ever think about how you are doing in your mathematics work?  
*No not really.*

Thank you for your help today.

## **APPENDIX I: POST-STUDY INTERVIEW SCHEDULE**

All interviews completed between 15<sup>th</sup> November 2004 and 15<sup>th</sup> December 2004, in school time between 9.00 am and 3.15 pm.

Hello..... . Today we are going to be doing our final interviews. Please speak clearly, so that the tape recorder will pick up your voice. Remember to say what you really feel and that what you say is completely confidential.

How did you feel when you first heard about the expert learning project? Did it make you more interested in learning mathematics?

How have you found filling in the reflective prompt? (Generally try and find their perceptions of the project – other questions may lead from this)

Did it (the reflective prompt) help you concentrate?

Did it (the reflective prompt) remind you to do certain things? What?

Do you know what expert learners do? (if yes - what ?)

Do you get help from others in your mathematics class?

What is your favourite subject?

What do you think of mathematics?

How do you know that you have learnt something in mathematics?

Does the reflective prompt ever annoy you?

Would it help if you could write down problems that you had. For instance if you weren't enjoying it nor understanding it, the teacher could read what you had written and then change the next lesson to help you with these. What do you think?

Thank you.

## APPENDIX J: POST- STUDY STUDENT INTERVIEW

### TRANSCRIPTS

#### Excerpt from Diane's transcript

How did you feel when you first heard about the expert learning project?

Did it make you more interested in learning mathematics?

*I thought it would give me a chance show me how to do maths an easier way. Yes it made me want to do it more.*

How have you found filling in the reflective prompt?

*I thought it would help me to find a goal and complete my goal pretty good. We had to write down the first part; we wrote down what our goal was. Then after 15 or 20 minutes we then had to write what you have learnt new and you would have to write down.*

What steps did you take?

*Firstly we took out our folder. You write the date and what your name was. It was sort of easy; it was hard cos there was some things that you asked us to remember. I got to write down what I had been learning. The steps was easy. Sometimes when you had to write down the goal of the lesson you wouldn't really know what it is.*

Did it make you think about what the goal was?

*Sometimes it did, if I did know what I was going to do then it did.*

Can you think of any more of what happened in the rest of the lesson?

*When the cymbals sound we would have to do part 2.*

Did it help you concentrate?

*Yes it helped me finish the pages.*

Did it remind you to do certain things?

*No.*

How did you find the class discussions: be really honest here:

*The discussions you have to tell you what we had learnt and I found it interesting to tell here what others had learnt.*

How did you feel about sharing your ideas?

*I didn't really do it much, because like I thought I would have got it wrong like didn't get it right.*

What could have made it better?

*Well if I really understood the work I did then I would have been more confident and then shared it.*

Do you know what expert learners do?

*They do the same, make up goals, try to complete it and find ways to help themselves do well in Maths.*

Did the reflective prompt remind you to do certain things?

*No.*

Does the reflective prompt ever annoy you?

*Sometimes I am doing my work and then I have to get it out.*

Would it help if you could write down problems that you had, for instance you weren't enjoying it not understanding it, the teacher then read what you had written and then changed the next lesson to help you? What do you think?

*Yes I think that would be good.*

Do you get help from others?

*Sometimes I ask Ann.*

What is your favourite subject?

*Art and sport.*

What do you think of mathematics?

*Interesting and a challenge.*

How do you know that you have learnt something in mathematics?

*If I find a different strategy then I know that I can do it.*

### **Excerpt from Bill's transcript**

How did you feel when you first heard about the expert learning project? Did it make you more interested in learning mathematics?

*I don't really mind. I thought it was strange how it was going to work but now that I know it's not that different.*

How have you found filling in the reflective prompt?

*Yes it is all right.*

Do you know what expert learners do?

*Study just before they think about what they have to do. They write things down if they are not that sure.*

Do you get help from others?

*No.*

What is your favourite subject?

*Sport.*

What do you think of mathematics?

*All right.*



How do you know that you have learnt something in mathematics?

*When I revise it seems easier.*

Does the reflective prompt ever annoy you?

*No.*

Would it help if you could write down problems that you had, for instance you weren't enjoying it not understanding it, the teacher could then read it and then change the next lesson to help you with these? What do you think?

*Yes I'd like that.*

### **Excerpt from Jason's transcript**

How did you feel when you first heard about the expert learning project? Did it make you more interested in learning mathematics?

*Didn't really mind it.*

How have you found filling in the reflective prompt?

*It does not really bother me. We had every couple of minutes we had to fill out the prompt how our maths was going.*

When you answered the questions did it make you think?

*No it didn't really help me that much.*

Can you talk me through that?

*Because it really just asks me questions and I was doing my maths anyway. Yeah well I understood it so it didn't really matter.*

So what was your overall impression of the reflective prompt?

*It didn't really help me that much, I didn't think it was that good.*

How did you think the class discussions went at the end?

*Well not many people talked.*

Yeah I agree because they were a bit shy at talking about how their maths is going. You knew what the maths was about, why didn't you share it?

*I was shy.*

What do you think of mathematics?

*I don't think it's very good.*

How do you know that you have learnt something in mathematics?

*When I get it right.*

## APPENDIX K: INTERVIEW WITH THE TEACHER

Thank you for being willing to take part in this interview. First of all can I assure you that you will remain completely anonymous and that no records of the interview will be kept with your name on them.

How long have you been teaching for?

*20 years.*

Could you tell me a little bit about your teaching history?

*My background was in South Africa. I taught in government schools for four years. Catholic school for nine years. When I came to Australia I taught in a Government school and went to the country. Then I did relief in Catholic schools and then here.*

How do you feel about the different subjects that you teach?

*Mainly just ones that I've taught the most; health, maths english. Not sure about science and history.*

Do you enjoy teaching mathematics?

*Most of the time. If I have a good group of children that are good it's challenging.*

What teaching approaches do you find work well in the mathematics classes?

How do you find group work activities?

*In some areas it's good that they get to talk to each other. I think there's a place for every type of strategy.*

Could you explain how the mathematics curriculum is organised in the school?

*We do have a syllabus that we follow. We can use which textbook we want to use in the year level. It is based on the government one [seemed to have no awareness that this is not been followed now in government schools]. I decide whether to teach this depending on whether it's in the syllabus I check this. Maybe just mention it as extension. I do allow it for extension.*

What support is there for children with special mathematical needs?

*There is physical support, a teacher comes in for 1 hour. Otherwise they work at work sheets at a remedial level.*

How enthusiastic are the children about learning mathematics?

*I have a good group. In one case where there was  $c=n$  [algebra] we had a go. I have some very weak children too.*

What differences do you find between the boys and girls when they tackle maths?

*On the whole boys seem to want to have a go at problems. Girls will sit back.*

Do you have anything else that you would like to share about teaching mathematics to this year 6 class?

*I feel that sometimes this class would like concrete materials but this school does not have many for this age group. Sometime they still need this. i.e. Simple scales. They do have one game: numero.*

Thank you for your time today.

## **APPENDIX L: SAMPLE EXTRACTS FROM CLASSROOM**

### **NOTE-TAKING**

#### **1st Phase Sample - Thursday 5/8/2004, 9.00am - 10.00am**

Children working in whole class setting. They are getting better at filling in journal. They are not sharing their ideas that much though. It is difficult to talk with the arrangement of the chairs. Special needs group had support today from Mrs Baxter with help on how to fill in the reflective prompt. Support teacher Mrs Baxter says: "Filled it in very well".

Downs syndrome girl who is not taking part in the study is really disrupting the class. The questions at the end that I have asked the children have been slightly modified to reflect what they have been learning about. This makes it slightly more relevant. Due to class of 32 they children are being left to their own devices a lot and it is appearing to me that the reflective prompt really needs a scaffold.

Do some reading on this approach – Browns Collins and Duguid. What are the children doing when they answer "no" in their reflective prompt; do they act on their responses?

#### **1st Phase Sample - Wednesday 25/8/2004, 9.00am - 10.00am**

Topic today is Equality and Inequality. Delia is working with Leah and they are understanding it and working well. Phillipa showing understanding to a certain extent. She is very under-confident. Not sure of one or two things yet made no attempt to show this on reflection sheet. It didn't do its job [the reflective prompt] because she doesn't like to show that she does not understand the question 100 divided by 5 is greater than 5 multiplied by 4. She guessed the answer; she didn't know what it is. I said to her "100 divided by 5". She then used short division (5 lots of 20) found out 20 quickly said "Oh" and then moved on. Didn't want to be found out. I tried to show her that it was the understanding that was important. [need to value children for what they are otherwise learning is going to be inhibited]. Children generally working confidently. Ann saying "this is so easy" She understood "greater"

and “less than” so easily that she didn’t see the point. I tried to motivate her and explained that in your test this – “Greater than, less than and BIMDAS” might be useful.

Towards the end of the lesson the children started to lose concentration. Getting a bit tired. Children were keen to contribute to reflective class discussion.

Children filling in the reflective prompt really well today with minimum disruption. They are not talking to their friends but overall the discussion is getting better.

## **2nd Phase Sample - Wednesday 10/10/2004, 9.00am – 10.00am**

Lesson Content is Range, Mode, Median and Mean

### **Start of lesson**

Mental Maths 8.45 am

Ten-minute challenge practising multiplying and dividing, addition and subtraction. Children working on this in complete silence. Some children still using fingers. David finished very quickly. Still a big range in the speed that the children are working. Even though it’s mental arithmetic, some children are still using pencil and paper method to work it out.

### **Middle of lesson**

Today the children are going to be learning about range, median, mean and mode. Use in real world discussed. Children have to find what it means – read, see in dictionary and make sense of it. Initial discussion about range – children found it quite hard though reading to grasp. Teacher explains that “mean” generally is what we think of as average. Teacher explaining and children sitting at their desks and listening. Children are sitting very quietly. Then children started MTS page 157, children completing the exercise. Filled in reflective prompt Joshua did not want to fill in reflective prompt. Anthony working with Sarah, they are now sitting pairs, which encourages to children to help each other. Jill and Peter just come up with the right answer didn’t know how. Boys going to blow noses – the only way they can get out of their seat. Filled in reflective prompt a second time. Joshua and Anthony complete reflective prompt. David writes that he does not does not find activity interesting. They all complete prompt effectively.

### **3rd Phase Sample - Wednesday 24/11/2004, 11.10am – 12.10.00am**

Teacher is Miss Smith

Concentrating on Delia, Debbie, Karen, and Peter

Goal of mathematics lesson - Division

Children working individually

Is layout normal? - Yes

They are working on division of decimals. There was no introduction with the children; just started working on mathematics exercises in MTS. Some of the children are working and some are talking. Miss Smith sitting at the desk marking. They are involved in carrying and working out remainders. The room is quite noisy next door. The cymbal is rung 5 minutes into the lesson.

#### **First completion [of reflective prompt]**

Debbie understood the concept and filled it in answering yes to most items.

Karen filled in the sheet she understands what to do.

Delia filled it in accurately.

Daisy forgot what the lesson was about, then remembered and was able to fill this section in. She has got some extension work and has been give the Year 7 book to complete.

#### **Mid completion [of reflective prompt]**

All children completed satisfactorily.

Toni, Daisy, Margaret and David are working on Year 7 decimals – These children are working on Year 7 book – half class working on Year 6 MTS. Very noisy next door making it hard to concentrate. Some of the boys struggling to concentrate. Atmosphere very relaxed. Lesson ending.

Teacher: “Close your book and go to sport”

Some children laughing — no chance for me to do final reflection. Today there was no real intensity to learning experience. Most of the children understood concepts though and Mrs Baxter was in working with her small group.

**APPENDIX M: SAMPLES OF CHILDREN'S COMPLETION OF  
REFLECTIVE PROMPT**

**Week by 24/10/04 Reflective Prompt Name:** Ann

**Monday**

**Planning (complete after 10 minutes)**

**What is the goal of this lesson?** *Teaching multiplication  
by 10, 100, 1000*

**How can I do this activity?** *multiplication skills*

**What am I good at that will help me?** *multiplication skills*

**Do I have to really concentrate?** Yes  No

**Do I enjoy this activity?** Yes  No

**Do I have everything that I need?** Yes  No

**Mid action reflection (share your ideas with someone)**

**Is the way I chose to solve this work working?** Yes  No

**Do I understand what I am doing?** Yes  No

**Am I making progress towards my goal?** Yes  No

**Is this activity interesting?** Yes  No

**Do I feel confident?** Yes  No

**Have I got everything I need?** Yes  No

**Am I giving myself enough time?** Yes  No

**Notes about my mathematics learning (use space on the back if needed)**

Figure 16. Ann using the reflective prompt to reflect on her learning

Week <sup>25</sup> ~~24~~/10/04 Reflective Prompt Name: Peter

Monday

Planning (complete after 10 minutes)

What is the goal of this lesson? work

How can I do this activity? work

What am I good at that will help me? nothing

Do I have to really concentrate?  Yes  No

Do I enjoy this activity?  Yes  No

Do I have every thing that I need?  Yes  No

Mid action reflection (share your ideas with someone)

Is the way I chose to solve this work working?  Yes  No

Do I understand what I am doing?  Yes  No

Am I making progress towards my goal?  Yes  No

Is this activity interesting?  Yes  No

Do I feel confident?  Yes  No

Have I got everything I need?  Yes  No

Am I giving myself enough time?  Yes  No

Notes about my mathematics learning (use space on the back if needed)

Figure 17. Peter using the reflective prompt to reflect on his learning



Week by 23/08/04 Reflective Prompt Name: Leah

Name: Leah  
Monday

Planning (complete after 10 minutes)

What is the goal of this lesson? Solving number sentences using brackets first solving them left to right

How can I do this activity? using the bindas sign

What am I good at that will help me? bindas

Do I have to really concentrate? Yes/No

Do I enjoy this activity? Yes/No

Do I have every thing that I need? Yes/No

Mid action reflection (share your ideas with someone)

Is the way I chose to solve this work working? Yes/No

Do I understand what I am doing? Yes/No

Am I making progress towards my goal? Yes/No

Is this activity interesting? Yes/No

Do I feel confident? Yes/No

Have I got everything I need? Yes/No

Am I giving myself enough time? Yes/No

Notes about my mathematics learning (use space on the back if needed)

Wednesday

Planning (complete this after 10min)

What is the goal of this lesson? Number sentences

How can I do this activity? using different patterns

What am I good at that will help me? patterns I've learnt

Do I have to really concentrate? Yes/No

Do I enjoy this activity? Yes/No

Do I have every thing that I need? Yes/No

Mid action reflection (share your ideas with someone)

Is the way I chose to solve this work working? Yes/No

Do I understand what I am doing? Yes/No

Am I making progress towards my goal? Yes/No

Is this activity interesting? Yes/No

Do I feel confident? Yes/No

Have I got everything I need? Yes/No

Am I giving myself enough time? Yes/No

Notes about my mathematics learning (use space on the back if needed)

Great

/

Figure 18. Leah using the reflective prompt to reflect on her learning (1)

Leah

Thursday

Planning (after 10 minutes)

What is the goal of this lesson? ... reviewing prime and composite numbers

How can I do this activity? ... using different numbers

What am I good at that will help me? ... composite numbers

Do I have to really concentrate? Yes No

Do I enjoy this activity? Yes No

Do I have everything that I need? Yes No

Mid action reflection (share your ideas with someone)

Is the way I chose to solve this work working? Yes No

Do I understand what I am doing? Yes No

Am I making progress towards my goal? Yes No

Is this activity interesting? Yes No

Do I feel confident? Yes No kind of

Have I got everything I need? Yes No

Notes about my mathematics learning (use this space for ideas from Monday Wednesday or Thursday)

Figure 19. Leah using the reflective prompt to reflect on her learning (2)

Phillipa

Week by 18/10/04 Reflective Prompt Names:

Monday

Planning (complete after 10 minutes)

What is the goal of this lesson? *review*

How can I do this activity? *remember what I have been taught*

What am I good at that will help me? . . .

Do I have to really concentrate?  Yes  No

Do I enjoy this activity?  Yes  No

Do I have everything that I need?  Yes  No

Mid action reflection (share your ideas with someone)

Is the way I chose to solve this work working?  Yes  No

Do I understand what I am doing?  Yes  No

Am I making progress towards my goal?  Yes  No

Is this activity interesting?  Yes  No

Do I feel confident? Yes  No

Have I got everything I need?  Yes  No

Am I giving myself enough time?  Yes  No

Notes about my mathematics learning (use space on the back if needed)

Wednesday

Planning (complete this after 10min)

What is the goal of this lesson? *range, mean, median, mode*

How can I do this activity? *listen*

What am I good at that will help me? . . .

Do I have to really concentrate?  Yes  No

Do I enjoy this activity? Yes  No

Do I have everything that I need?  Yes  No

Mid action reflection (share your ideas with someone)

Is the way I chose to solve this work working?  Yes  No

Do I understand what I am doing?  Yes  No

Am I making progress towards my goal?  Yes  No

Is this activity interesting? Yes  No

Do I feel confident? Yes  No

Have I got everything I need?  Yes  No

Am I giving myself enough time?  Yes  No

Notes about my mathematics learning (use space on the back if needed)

Figure 20. Phillipa using the reflective prompt to reflect on her learning

Week by 18/10/04 Reflective Prompt Name: Toni

Monday

Planning (complete after 10 minutes)

What is the goal of this lesson? To review our past terms lessons

How can I do this activity? By remembering my percentages, fractions and decimals

What am I good at that will help me? Percentages, fractions and decimals

Do I have to really concentrate? Yes  No  I find it simple

Do I enjoy this activity?  No  I ♥ Maths!

Do I have everything that I need?  No  Of course I do! ☺

Mid action reflection (share your ideas with someone)

Is the way I chose to solve this work working?  No

Do I understand what I am doing?  No

Am I making progress towards my goal?  No

Is this activity interesting?  No

Do I feel confident?  No

Have I got everything I need?  No

Am I giving myself enough time?  No

Notes about my mathematics learning (use space on the back if needed)

Wednesday

Planning (complete this after 10min)

What is the goal of this lesson? To learn about range, Median, Mode of numbers

How can I do this activity? Finding out what they are

What am I good at that will help me? Looking up words

Do I have to really concentrate? Yes  No  I know what they are

Do I enjoy this activity?  No  Maths is fun

Do I have everything that I need?  No

Mid action reflection (share your ideas with someone)

Is the way I chose to solve this work working?  No

Do I understand what I am doing?  No

Am I making progress towards my goal?  No

Is this activity interesting?  No

Do I feel confident?  No

Have I got everything I need?  No

Am I giving myself enough time?  No

Notes about my mathematics learning (use space on the back if needed)

Figure 21. Toni using the reflective prompt to reflect on her learning (1)

Toni

Thursday

Planning (after 10 minutes)

What is the goal of this lesson? To measure and learn to measure our hands  
to work out mean, mode, range, median

How can I do this activity by reviewing

What am I good at that will help me? maths

Do I have to really concentrate?  Yes  No

Do I enjoy this activity?  Yes  No

Do I have everything that I need?  Yes  No

Mid action reflection (share your ideas with someone)

Is the way I chose to solve this work working?  Yes  No

Do I understand what I am doing?  Yes  No

Am I making progress towards my goal?  Yes  No

Is this activity interesting?  Yes  No

Do I feel confident?  Yes  No

Have I got everything I need?  Yes  No

Notes about my mathematics learning (use this space for ideas from Monday Wednesday or Thursday)

Figure 22. Toni using the reflective prompt to reflect on her learning (2)

Diane

Thursday

Planning (after 10 minutes)

What is the goal of this lesson? find a new way to

help find real life percentages

How can I do this activity? I'm using a calculator

What am I good at that will help me? division

Do I have to really concentrate? Yes/No

Do I enjoy this activity? Yes/No

Do I have everything that I need? Yes/No (No)

Mid action reflection (share your ideas with someone)

Is the way I chose to solve this work working? Yes/No

Do I understand what I am doing? Yes/No

Am I making progress towards my goal? Yes/No

Is this activity interesting? Yes/No

Do I feel confident? Yes/No

Have I got everything I need? Yes/No

Notes about my mathematics learning (use this space for ideas from Monday  
Wednesday or Thursday)

I found this term very good because improved the way I do maths. I have done more pages than ever and it really helped me using the reflection sheets. It showed me what I needed to do and gave me a chance of finding new way to do math problems!



Figure 23. Diane gained in confidence from being able to express her ideas

John

Week by 22/11/04 Reflective Prompt Name:

Monday

Planning (complete after 10 minutes)

What is the goal of this lesson? .....

How can I do this activity? .....

What am I good at that will help me? .....

Do I have to really concentrate? Yes/No

Do I enjoy this activity? Yes/No

Do I have every thing that I need? Yes/No

Mid action reflection (share your ideas with someone)

Is the way I chose to solve this work, working? Yes/No

Do I understand what I am doing? Yes/No

Am I making progress towards my goal? Yes/No

Is this activity interesting? Yes/No

Do I feel confident? Yes/No

Have I got everything I need? Yes/No

Am I giving myself enough time? Yes/No

Notes about my mathematics learning (use space on the back if needed)

$$\begin{array}{r} 16 \text{ r } 2 \\ 3 \overline{) 50} \\ \underline{30} \\ 20 \\ \underline{18} \\ 2 \end{array}$$
  
or  
$$\begin{array}{r} 16.66 \\ 3 \overline{) 50.00} \\ \underline{48} \\ 20 \\ \underline{18} \\ 20 \\ \underline{18} \\ 20 \end{array}$$
  
I'm not understanding what to do with remainders

Wednesday

Planning (complete this after 10min)

What is the goal of this lesson? Review .....

How can I do this activity? .....

What am I good at that will help me? .....

Do I have to really concentrate? Yes/No

Do I enjoy this activity? Yes/No

Do I have every thing that I need? Yes/No

Mid action reflection (share your ideas with someone)

Is the way I chose to solve this work, working? Yes/No

Do I understand what I am doing? Yes/No

Am I making progress towards my goal? Yes/No

Is this activity interesting? Yes/No

Do I feel confident? Yes/No

Have I got everything I need? Yes/No

Am I giving myself enough time? Yes/No

Notes about my mathematics learning (use space on the back if needed)

Figure 24. John being directed by the researcher to use a different learning strategy

Catherine
<p>Week no <u>22/02/04</u> Reflective Prompt Name</p> <p>Name: _____</p> <p>Monday</p> <p><b>Planning (complete after 10 minutes)</b></p> <p>What is the goal of this lesson? <u>To do the sums as fast as we can and review long multiplication from last week.</u></p> <p>How can I do this activity? <u>By looking back on our work and listening to the teacher.</u></p> <p>What am I good at that will help me? <u>Listening</u></p> <p>Do I have to really concentrate? <input checked="" type="radio"/> Yes <input type="radio"/> No</p> <p>Do I enjoy this activity? <input checked="" type="radio"/> Yes <input type="radio"/> No</p> <p>Do I have every thing that I need? <input checked="" type="radio"/> Yes <input type="radio"/> No</p> <p><b>Mid action reflection (share your ideas with someone)</b></p> <p>Is the way I chose to solve this work working? <input checked="" type="radio"/> Yes <input type="radio"/> No</p> <p>Do I understand what I am doing? <input checked="" type="radio"/> Yes <input type="radio"/> No</p> <p>Am I making progress towards my goal? <input checked="" type="radio"/> Yes <input type="radio"/> No</p> <p>Is this activity interesting? <input checked="" type="radio"/> Yes <input type="radio"/> No</p> <p>Do I feel confident? <input checked="" type="radio"/> Yes <input type="radio"/> No</p> <p>Have I got everything I need? <input checked="" type="radio"/> Yes <input type="radio"/> No</p> <p>Am I giving myself enough time? <input checked="" type="radio"/> Yes <input type="radio"/> No</p> <p><b>Notes about my mathematics learning (use space on the back if needed)</b></p> <p><u>I find it boring when the teacher explains cuz I already know how to do it.</u></p>

Figure 25. Catherine expressing that she already knows how to do long multiplication despite learning activity teaching this



Ann

**Week by 22/11/04 Reflective Prompt Name**

Monday

**Planning (complete after 10 minutes)**

What is the goal of this lesson? *Division with decimals*

How can I do this activity? *Division*

What am I good at that will help me? *Division*

Do I have to really concentrate? *Yes/No*

Do I enjoy this activity? *Yes/No*

Do I have every thing that I need? *Yes/No*

**Mid action reflection (share your ideas with someone)**

Is the way I chose to solve this work, working? *Yes/No*

Do I understand what I am doing? *Yes/No*

Am I making progress towards my goal? *Yes/No*

Is this activity interesting? *Yes/No*

Do I feel confident? *Yes/No*

Have I got everything I need? *Yes/No*

Am I giving myself enough time? *Yes/No*

**Notes about my mathematics learning (use space on the back if needed)**

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Wednesday

**Planning (complete this after 10min)**

What is the goal of this lesson? *Number relations*

How can I do this activity? *Division*

What am I good at that will help me? *Division*

Do I have to really concentrate? *Yes/No*

Do I enjoy this activity? *Yes/No*

Do I have every thing that I need? *Yes/No*

**Mid action reflection (share your ideas with someone)**

Is the way I chose to solve this work, working? *Yes/No*

Do I understand what I am doing? *Yes/No*

Am I making progress towards my goal? *Yes/No*

Is this activity interesting? *Yes/No*

Do I feel confident? *Yes/No*

Have I got everything I need? *Yes/No*

Am I giving myself enough time? *Yes/No*

**Notes about my mathematics learning (use space on the back if needed)**

Figure 26. Ann expressing her ideas before asking the teacher to change the learning activity

## **APPENDIX N: CONTENT ANALYSIS**

Figure 27 shows the steps that were taken in the content analysis process. It began with the collection of data as outlined in Chapter 3. The data was initially analysed in order to identify different effects that occurred in the case study. This process created categories which were then further analysed and common patterns emerged. Additional investigation of the qualitative data enabled these patterns to be linked together so that four main constructs were identified. These constructs were the final step in this qualitative data analysis and produced the major effects of the expert learning process designed to promote number sense.

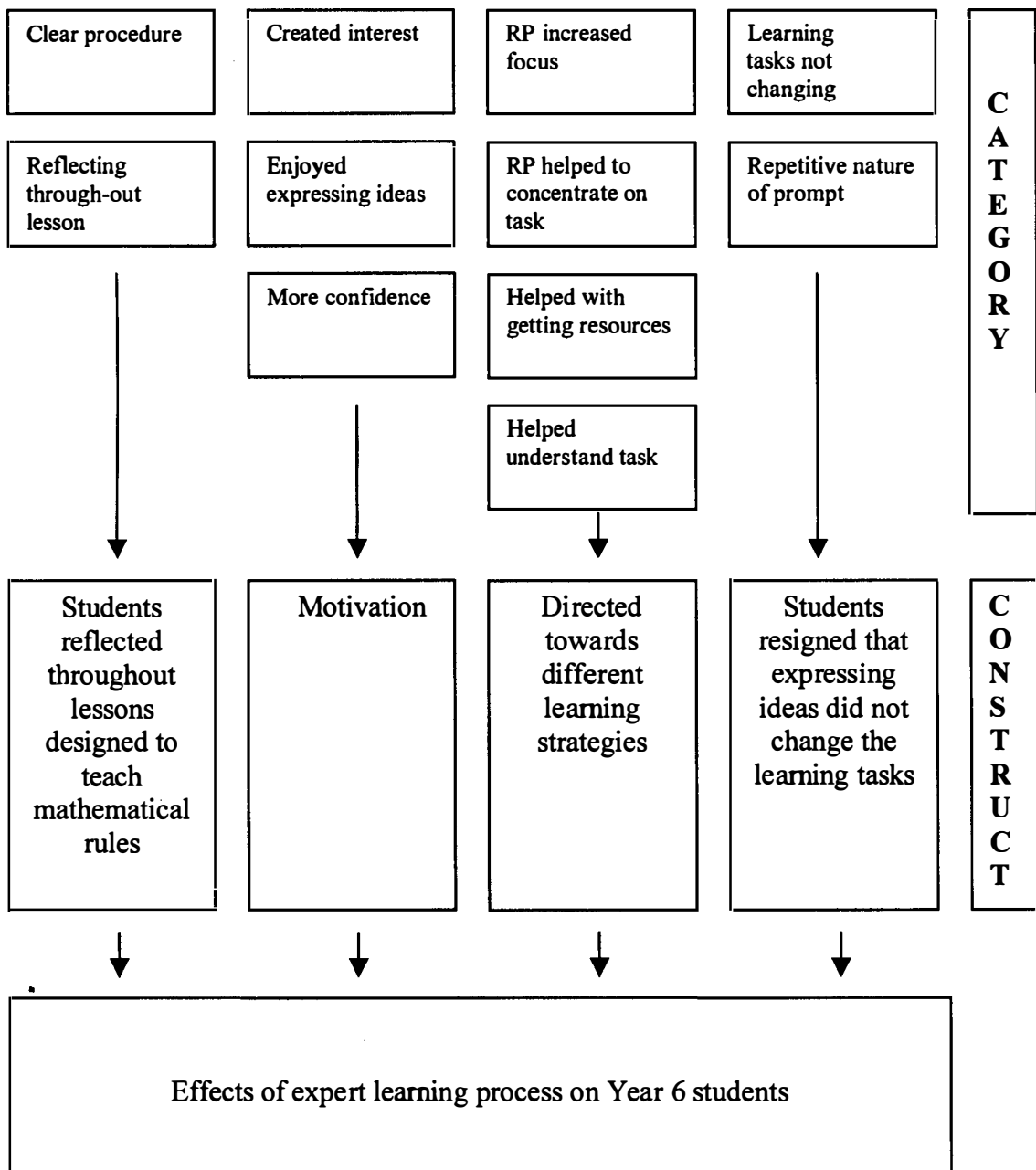


Figure 27. A diagram to show the flow of qualitative data analysis.