Rubric supported journal writing in mathematics.

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Abstract

Using an Action Research model, this project followed the implementation of a journal writing programme in mathematics, in a grade three (year 4) class. The effect of journal writing, as a formative assessment tool upon a single teacher's approach to the teaching and assessment of mathematics in her textbook-based, whole class mathematics programme, is the focus of the study.

The teacher who participated in this project looked towards the journal writing programme to assist her in making changes to her teaching and assessment practises in mathematics, in an effort to bring them in line with her performance based approach to other areas of the curriculum. Using Greenwood's (1993) criteria for mathematical thinking, rubrics were designed to make mathematical thinking a focus of her teaching and assessment in mathematics.

Several changes in the teacher's approach to the teaching and assessment of mathematics were observed within the study period and continued sustained changes were realised in the longer term. In addition, aspects of her teaching and assessment practices that were *not* observed to change are discussed. The suggestion is made that the potential of journal writing to be used to extend and challenge the mathematical thinking of students may be partly dependent upon the depth and breadth of the mathematical knowledge of the teacher.

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Chapter 1

Introduction

1.1 Background to the study.

Teaching and assessment practices in mathematics continue to adapt to the needs of a changing society (National Council of Teachers of Mathematics, 2000):

> "We live in a time of extraordinary and accelerating change. New knowledge, tools, and ways of doing and communicating mathematics continue to emerge and evolve.....The need to understand and be able to use mathematics in everyday life and in the workplace has never been greater and will continue to increase" (p 3).

To meet these changing needs, students are now required to develop and demonstrate skills in interpreting, explaining, justifying and applying mathematical thinking. To develop such skills, students *and educators* need to understand what defines a quality explanation (Bricknell, 1998). Ultimately, to support such learning, teachers need to understand, practice and model the mathematical thinking, behaviour and attitudes they expect to develop in their students.

Both the National Council of Teachers of Mathematics (1989, 2000) and the New Zealand Ministry of Education (1992) outline the importance of developing in students the skill of communicating mathematical ideas; of explaining and justifying mathematical thinking. Writing journals are a tool to develop communication skills in mathematics. Through regular journal writing, students are given the opportunity to practice and develop skills in thinking, explaining and justifying mathematical ideas. In addition, teachers are given the

opportunity to access the previously hidden mathematical thinking and understanding of their students.

Journal writing is a unique form of mathematical writing in that it is a private two way communication tool. Students write in their journals, and the teacher writes a response. In so doing, the student is provided with feedback in the form of support, guidance or challenge to expand their thinking or explanation. The private nature of journal writing provides an ideal opportunity for students to expose their own thinking, understanding and attitude in mathematics. Consequently, student journal entries have been found to give teachers valuable feedback about the effectiveness of their teaching and the individual mathematical needs of their students. Such feedback, if understood and interpreted carefully, can guide teachers in the modification of their teaching practices. Through writing responses to student journal entries, teachers are given the opportunity to model mathematical thinking and positive attitudes towards mathematics.

1.2 Rationale for the study

While much has been written about the benefits of journal writing to both the students and teachers, most of this research has taken place in junior elementary classes, or secondary schools (e.g., Chapman, 1996, Liedtke & Sales, 2001, Mayer & Hillman, 1996, Miller, 1990). Limited research is available on the implementation of writing journals in middle elementary classes. This is significant, as the majority of elementary teachers do not have a strong background in mathematics and lack expertise and confidence in their teaching and assessment of the subject (McIntosh, 1988).

Research shows that writing journals can be both an effective teaching tool and an effective assessment tool in mathematics (Bagley & Gallenberger, 1992, Gordon & MacInnis, 1993, Miller, 1990, 1992a, 1992b, 1993, Thompson, Thompson & Else, 2000). The potential of journal writing to impact upon the

teaching and assessment practices of individual teachers is dependant upon the teacher's ability to:

- Recognise the mathematical significance of a student's journal entry
- Interpret the mathematical thinking of individual students
- Know how to use that information to further the individual student's learning and understanding of mathematics.

There is a need to explore ways in which teachers lacking in mathematical expertise can be supported and guided in the implementation and use of journal writing in mathematics. Informal interviews with colleagues about the implementation of journal writing in mathematics led me to understand that many teachers, who have avoided implementing writing as a regular part of mathematics, struggle to understand *how* to get students to write, and *what* to get students to write about. This project provided the opportunity to explore the use of prompt categories (DiPillo, Sovchik & Moss, 1997) to guide and suggest the formulation of prompts for a teacher implementing journal writing for the first time.

The international school, at which this project took place, supported and promoted the use of performance based rubric assessment techniques. However, informal interviews with colleagues at this school revealed that such assessment was not widely practiced in mathematics. This indicated an opportunity for this project to adapt assessment techniques already in place in other areas of the curriculum, to support, and possibly guide, the implementation of writing journals in mathematics.

Documents that influence contemporary reform in mathematics education (e.g. National Council of Teachers of Mathematics, 2000) speak frequently of the need to focus on, develop and monitor mathematical thinking in students. Greenwood's (1993) seven criteria for developing mathematical thinking in students provide a useful guide for teachers who lack expertise and confidence in mathematics, to assist in the recognition and development of students'

mathematical thinking. A seriated rubric based on these criteria, could guide the teacher in what to promote, model and look for in her students. At the same time, such a rubric might be used by students to self assess, and therefore further promote, mathematical thinking. There was the opportunity for this research project to explore the use of mathematical thinking criteria, in rubric form, to support the implementation of a journal writing programme in mathematics, in a way that might maximize the potential for journal writing to affect the teaching and assessment practices of the teacher.

Ultimately, the rationale for this action research project was to support an individual teacher, who lacked expertise in mathematics, to use journal writing to assist her to reformulate her teaching and assessment of mathematics in line with her teaching and assessment of other areas of the curriculum.

1.3 Research objectives

The primary aim of this study was to find out how a teacher, who runs a primarily textbook based mathematics programme, is able to use writing journals as a teaching and assessment tool in her mathematics programme. The effect of the writing journals on this teacher's assessment practices in mathematics and on her approach to teaching mathematics have been specific areas of focus throughout the project. In addition, particular attention has been given to the teacher's existing rubric based assessment practices in other areas of the curriculum. A related objective was to determine if writing journals and rubrics (that make thinking, understanding and communication the focus of attention) can assist the teacher to reformulate her teaching and assessment of mathematics.

Specifically, the following research questions have been addressed:

How does the implementation of a journal writing programme affect the teaching approach of a teacher?

- Is the teacher able to take ownership of the journal writing programme?

- Is there a change in her lesson planning, the way she groups her students, or in the way she uses the textbook?
- Does she begin to provide mathematical learning opportunities outside of the textbook?
- Does she use the journals effectively as a communication tool?
- Is she able to formulate prompts effective in stimulating thoughtful and revealing responses from her students?

How does the implementation of a journal writing programme influence the teacher's assessment of her students in mathematics?

- Is there a change in the recording of assessment data?
- Is there a change in the selection of material for inclusion in the portfolio?
- Is there a change in the involvement of the students in the assessment of mathematics?
- Is there an increase in the teacher's confidence in her teaching and assessment of mathematics?

To what extent can generic rubrics be used to keep a record of student progress in thinking and communication in mathematics? How much does journal writing contribute to such assessment?

- Are we able to formulate generic rubrics that make thinking, understanding and communication the focus of attention in mathematics teaching and assessment?
- Are we able to formulate a rubric to specifically record growth in mathematical thinking, understanding and communication exposed through journal writing?
- Does the teacher use students' journal writing as evidence for assessment while using the rubrics to assess students in mathematics?
- Do the rubrics influence her approach to journal writing?

1.4 Definition of terms

For the purpose of this project, journals for writing in mathematics consisted of an exercise book. This book was written in by students two or three times a week, during regular mathematics sessions, in response to prompts supplied by the teacher. After reading the student responses, the teacher wrote back in the form of a comment or suggestion for further thinking. In some cases, the teacher's response was in the form of a re-prompt, requiring the student to reply with a further response. In this, writing journals were a private communication tool between the teacher and students.

Prompts consisted of either questions for students to answer, statements for students to comment on, or directions for students to explain an idea, attitude or procedure. These prompts were either preplanned, with the aim of exposing student learning or understanding in line with pre-established learning objectives, or they were impromptu prompts resulting from activity during a particular mathematics session and aimed at revealing the effectiveness of a given lesson (Miller, 1992b, 1993).

During this research project, generic rubrics were formulated. A rubric is an evaluative tool. It is an array of descriptions that define a continuum of product quality from very poor to very excellent (Hibbard, 1996). These rubrics are used to assess product quality but also have the duel benefit of guiding both the teacher and the student in understanding what defines product quality. Research shows that carefully formulated rubrics can provide a framework against which teachers and students can work, improving student performance in mathematics (Arter & McTighe, 2001).

1.5 Chapter overview

Chapter one introduces the project, outlining the aim of the study and specific research questions.

Chapter two reviews the literature relevant to this project. Specific topics covered during this review include:

- Using thinking criteria to make mathematics learning centered
- Contemporary assessment practices, with particular emphasis on formative assessment and it's affect on further instruction
- Rubrics
- The role of writing in mathematics
- The unique nature of journal writing in mathematics and how it can contribute to both the teacher's and the students' overall learning and assessment.

Chapter three discusses the methodology for this project, explaining the particular situation in which this project took place and why an action research model was adopted. An outline of the planning for this project is given.

Chapter four describes what actually took place during the research period of this project. Details are given of the planning sessions between the teacher and researcher that influenced the direction of the project, and the three action research cycles of implementation, reflection, and evaluation that followed.

In chapter five, the project results outlined in chapter four are discussed and an assessment is made of the projects contribution to answering the research questions outlined in chapter one.

Finally, chapter six closes the research with a discussion of the long-term effects of the study and it's contribution to an understanding of the potential for journal writing to effect the teaching and assessment practices of teachers in general. Suggestions for further research are also identified.

Chapter 2

Literature Review

2.1 Introduction

The mathematics curriculum in many nations has undergone, and continues to undergo, significant changes in emphasis (Ehrich, 1994). There is a move away from content-based programmes, towards more student-centered curriculums with greater emphasis on process and communication (NCTM 1989, NCTM, 2000, Ministry of Education, NZ, 1992, 1995, International Baccalaureate, Primary Years Programme, 2000). Students are now required to explain their methods and reasoning using correct mathematical terms. They are required to explain their thinking and strategies and to suggest alternative ways of tackling problems (The National Numeracy Strategy, DIEE, 1998 cited in Mitchell & Rawson, 2000). Likewise, teachers are expected to facilitate and assess progress in the development of mathematical thinking and explanations.

Following is a summary of research that supports the move towards student-centered, formative assessment and suggests ways in which educators can make this move. This includes the use of thinking based criteria, generic rubrics that encourage student self-reflection, and writing journals in mathematics.

2.2 Making mathematics learning centered

Prawat and Jennings (1997) observed in teachers a tendency to see mathematics as content, leading to activity based programmes rather than mathematics that is learning centered. They suggest that ongoing, well supported and directed formative assessment may assist in reversing such perceptions of mathematics, and promote mathematics as learning centered rather than content that has to be covered before the end of the year.

Greenwood (1993) argues that mathematical thinking should be the focus of learning rather than the mere by-product of learning and doing mathematics it has traditionally been. He suggests that mathematical thinking implies a systematic approach to quantitative problems. Greenwood (1993) looked at the following statements that began two of the first three Standards for Teaching Mathematics (as presented by the National Council of Teachers of Mathematics 1991):

> The goal of teaching mathematics is to help all students develop mathematical power and... all students can learn to think mathematically.

In an attempt to better align the teaching and learning of mathematics with the development of mathematical thinking and mathematical power, as suggested by NCTM's Standards for Teaching Mathematics (1991), Greenwood (1993) lists seven criteria for mathematical thinking. These criteria "form the basis for establishing a classroom environment that advances the notion that mathematics is a way of thinking" (p148). They include:

- Everything you do in mathematics should make sense to you: Students are expected to explain their strategies and thoughts so they are clearly understood by others, not just repeat the steps of what to do to get there.
- Whenever you get stuck you should be able to use what you know to get yourself unstuck: Students need to learn to build on what they know. They need to learn to question themselves.
- You should be able to identify errors in answers, in the use of materials, and in thinking: Students can learn a great deal from their errors if they are willing to think about them once they have been spotted.
- When the strategy you are using is not working, you should be willing to try another strategy instead of giving up: Students are expected to think for themselves as much as possible, challenging themselves to work their way out of tight spots independently, without the help of the teacher.

- Whenever you do a computation, you should use a minimum of counting.
- You should be able to perform calculations with a minimum of rote pencil-paper computation.
- You should be able to extend a problem situation by posing additional conditions or questions.

Greenwood discusses ways in which to make these seven criteria part of the everyday learning programme. Incorporating writing journals into the regular mathematics programme is one way of achieving this. At the same time, the promotion and consideration of Greenwood's criteria for mathematical thinking may support and direct journal writing, assisting both the teacher and the students to recognise the value of exposing thinking and understanding.

In an effort to promote mathematics that is learning centered, assessment practices have been reviewed. Kouba (1999) discusses the challenges and opportunities for thoughtful reflection on practices that arise from the current curricula and assessment shift towards activities that are embedded in contexts. This includes the current move to create authentic assessment tasks and the development of test questioning techniques that challenge children to do more than repeat or work through a rote learned algorithm (de Lange, 1993). Alternative test formats require students to interpret a mathematical problem, explain their thinking as they solve the problem, and to justify their solution. Students need to be given opportunity to explain their interpretation of mathematical problems. Without such opportunity, Kouba says, it is not always possible to assess the reasonableness of a student's response to a mathematical question. Kouba goes on to describe situations in which students, given the opportunity to explain their interpretation, are able to expand a given problem, making their learning and understanding of mathematics relevant to real world experience. It takes time and practice to develop skills in explaining and justifying mathematical thinking in the way Kouba suggests (Bicknell, 1998). Journal writing may be one forum in which teachers can assist students to practice this regularly.

2.3 Assessment

Gardener (1992, cited Kulm, 1994, p3) defines assessment as the "obtaining of information about the skills and potentials of individuals, with dual goals of providing useful feedback to the individuals and helpful data to the surrounding community". Ultimately, assessment is a two-way communication between learner and teacher, serving as an essential link between curriculum, teaching and learning (Harris & Bell, 1994, Wilcox, 1997).

Generally, summative assessment is assessment carried out in the form of testing, grading or report writing, mostly for external reasons. It most often comes at the end of a unit of study and may take the form of a single grade or a comprehensively written comment. It may come from the grading of a test or the assessment of an open ended learning exercise. Generally, but not always, summative, or end point assessment, falls short of facilitating learning in that it reports on a particular performance and may not necessarily enable or encourage follow up learning or teaching (Harris, 1994).

"Formative assessing is about using the process and results of assessing to influence (hopefully to facilitate) the learning process" (Harris, 1994, p.99). It is generally ongoing, with written comments, or even grades, used to stimulate thought and discussion on student learning. Ideally, formative assessment is carefully planned and followed up on, giving students the maximum opportunity of demonstrating and improving learning and understanding.

Alternative, or rich assessments are broad terms used for assessment methods that enable teachers to integrate assessment with the instructional process. This ensures a much clearer and more useful picture of student performance, understanding, thinking and attitudes than more traditional assessment allowed (Harris & Bell, 1994, Kulm, 1994, Micko, 1997, Pressley & McCormick, 1995). As suggested by Harris and Bell, these assessment methods tend to be more informal than formal, and formative or ongoing rather than end point tests or summative. They allow for a balance between process

and product based assessment (as opposed to the more product based approach of traditional methods), and allow for more group focused assessment as well as individual. Alternative assessment includes the possibility of a balance between learner judged and teacher judged collaborative assessment, encouraging the learner to be more involved in their own learning and assessment.

Sgroi, Gropper, Kilker, Rambusch and Semonite (1995), studied the ways in which changes in the manner of evaluating young children's mathematical comprehension can yield a clearer understanding of individual growth in thinking and reasoning. They followed the experience of one kindergarten class in the USA, which discarded the paper-and-pencil type standardised test to concentrate on the formative assessment of a graphing activity, which allowed for follow-up questioning. They found that much more information about student thinking and reasoning was available through the activity-based assessment than through the traditional pencil-and-paper test. Teachers were able to assess and follow up on learning outcomes over and above those originally sought. In the spirit of formative assessment, Sgroi et al. (1995) suggest that there should be little difference between what is being learned and what is being assessed. "Assessment incorporated into the everyday routines of a classroom allows the teacher to monitor individual growth constantly and plan for consequent activities" (p 275).

The use of open-ended questioning (including open-ended prompts for journal writing) that allows students to expose the thinking behind their mathematics, provides opportunity for the teacher to make effective and immediate assessment judgments. As outlined by the Mathematics Curriculum in New Zealand (Ministry of Education, 1992), worthwhile diagnosis of student understanding and concepts can be carried out by question and answer interaction within the classroom. This type of assessment opportunity can quickly reveal a student's misconception or talent, guiding the teacher's planning. Open-ended questioning enables teachers to ground their diagnosis

of student understanding within the context of the classroom activity. In turn, by observing, considering and attempting to understand the knowledge and understanding that students reveal through their responses to open-ended questioning, teachers are better able to understand for themselves the content of the mathematics they are teaching, the significance of this content, and how it contributes to the overall mathematical learning their students are expected to experience (Ball & Bass, 2000). Teachers need to be able to identify the content knowledge that matters in mathematics, understand ways in which students may express such knowledge and what it takes to teach such knowledge. Without an appreciation of the significance of a student's revealed mathematical thinking, open-ended questions loose their value as a diagnostic tool and can merely become confusing activities for both student and teacher. Clear rubrics, or seriated standards, that focus attention on declarative, procedural, conditional and metacognitive knowledge*, may go some way to guide the teacher in what defines growth in mathematical learning, as they observe or communicate with students.

The value of open-ended questioning as an assessment tool is enhanced with effective recording of assessment judgments. Informal, formative assessment includes the observation and recording of significant responses. Significant responses demonstrate particular insights, and reveal new, previously unexposed thinking behind an action, or a misconception that needs addressing or appears to be in the process of adjustment (Sullivan and Clarke, 1991). These recorded observations may be triggered by the need to assess across a set of standards or specific learning outcomes, and may be an alternative to a test or standardised pencil-and-paper assessment task. Recorded significant observations contribute to an ongoing, open-ended profile of student learning. Such records, when carefully kept over a year can build a profile of student progress. Writing journals, in which students record their ideas, and teachers record their responses to these ideas, may contribute significantly to an on-going, open-ended profile of student learning.

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* Main categories of knowledge as described by Paris, Lipson and Wixson, (1983).

2.4 Influencing change in assessment of mathematics

"The belief that average-ability students are incapable of higher-order thinking and the mistaken notion that the body of knowledge and skills that students must learn is fixed or delimited by the discipline [of mathematics]" are myths commonly held by teachers that may constrain attempts to alter teaching and assessment practices in mathematics (Prawat and Jennings, 1997, p251).

Bush (1998) explored the reasons why teachers might change methods of assessment. He discovered that the motivation to change could be either intrinsically or extrinsically driven. Extrinsically, a teacher may be motivated to change assessment techniques to align with new curriculum demands. Intrinsically, a teacher may be motivated to change assessment techniques in an effort to find out more information about their student's learning and understanding or the effectiveness of their teaching.

Prawat and Jennings (1997) wrote about the experiences of two upper-elementary schoolteachers as they attempted to implement elements of educational reform in mathematics as part of a statewide effort in California, USA (an extrinsic motivation to change). This education reform emphasised open-ended activities to promote communication and problem solving in mathematics. Such change is not easy. Prawat and Jennings (1997) revealed that teachers found it difficult to change long held perceptions about mathematics teaching and learning. Their study findings suggest that external motivation to change may be insufficient without support and guidance for teachers to change their mindset. External motivation to change needs to come with clear guidelines that influence teachers' perception of mathematics from content based, to incorporate a focus on student thinking, learning and understanding.

For changes in assessment methods to be fully accepted and effective teachers need to be motivated to change intrinsically by a need to understand

more about their students' learning of mathematics and by their need to reflect on the effectiveness of their teaching (e.g. Mayer and Hillman, 1996, Miller, 1992a). Any reform in mathematics curriculum and assessment will inevitably be influenced by teacher beliefs and attitudes. The implementation of a journal writing programme in mathematics may benefit from the support of criteria or guidelines that guide teacher focus towards student thinking and understanding, to provide feedback that stimulates an intrinsic desire in the teacher to find out more about student thinking, learning and understanding, and the effectiveness of their teaching programme.

2.5 Assessment to affect further instruction

Assessment that provides a teacher with feedback about the effectiveness of a lesson, programme or approach, has the potential to affect further instruction. Bagley and Gallenberger (1992) are among many researchers who are able to present evidence of journal entries being used as an evaluation tool to affect future planning, particularly in the short term. Journal entries are read, responded to and reacted upon quickly, opening the flow of communication between student and teacher. The journal itself and the teacher's written responses provide a record of evidence that contributes to an overall assessment judgment of student learning in mathematics. This evidence provides feedback to the teacher indicating the need for further instruction or clarification.

In their one year study of grade 4-6 students, Gordon and MacInnis (1993) also used students' journal entries as a communication link between students and teachers, and as a guide to affect instructional decisions. Students were given prompts to write to and also free writing time in which to write on any aspect of their mathematics learning they wished. After reading the student's journal entries, teachers would respond accordingly with either support for a student's comment or a prompt for further consideration by the student. Assessment judgments were made as journal entries were read, and further guidance was given through the teacher's response, or, in some cases, by a

follow-up lesson or interview. Gordon and MacInnis found that the individual and private nature of the students' journal entries guided them to adjust their instructional approaches:

> "Information gleaned from the journal entries allowed guidance and instruction on a more individualized level. It allowed us the opportunity to reflect on the teaching/learning process and to better meet the instructional needs of each of the students" (p. 42)

Kathleen Chapman (1996), a high school teacher in USA, found journal assignments to be "extremely valuable for diagnosing and troubleshooting misconceptions" (p 588). She used what she discovered from reading students' journal entries to aid her planning and as a basis for revising her teaching strategies. Chapman felt the information gleamed from reading her students writing was well worth the time spent responding to them. She found that she was able to focus on individual student understanding and thinking in mathematics, enabling her to affect her teaching to better meet the individual needs of her students.

To maximize the effect of writing journals in mathematics, teacher responses need to be carefully considered. They require at least the consideration of a written response and often a follow up learning or clarification activity. This is another activity added to a teacher's already very long list of activities required for the smooth and effective running of a class. As such, many researchers noted that journals are usually best regarded as an informal, non-threatening and relatively private method of gathering information from the students as to their thinking, understanding and feelings about mathematics (McIntosh, 1991). Any form of formal assessment (for example, the assigning of grades or levels of achievement for recording on a student profile) has to be carefully applied in an effort not to undo these criteria.

Elementary students were often found to be motivated to write in their journals through the pleasure of communicating with a teacher who they felt was listening to them, and by the intrinsic reward they experienced from reading their teacher's response to their journal writing (Gordon and MacInnis, 1993; McIntosh, 1988). On the other hand, Chapman (1996) observed that senior students in high school or tertiary levels were more likely to take a mathematical activity seriously if they thought it would be assessed and contribute to a grade. To this end, some high school teachers (Chapman, 1996, Miller, 1992a, Mayer and Hillman, 1996, McIntosh, 1991) begin a journal writing programme, by using grading as an incentive for students to write, commonly in the form of 'active participation' grades. As teachers (and students) become more experienced with using the journals as an alternative form of assessment, these teachers begin to set standards against which to assess the correct usage of language, thoroughness, and level of justification. Caution needs to be observed with any such grading system however, to ensure that it does more than merely encourage students to formulate their writing, but rather encourages in students the development of mathematical thinking and learning.

Ciochine and Polivka (1997) discussed the use of writing as a tool for teaching and assessing mathematics within the context of a 'Problem of the Week' programme. Students were required to write their solution to an open-ended weekly problem including a description of the method they employed in reaching the solution. Both student and teacher recorded an assessment of the student's performance of this task on a set form. Transferring the assessment of the problem of the week onto a standard form that is used weekly, provided a format against which to plot progress of student learning. Not only were the learning outcomes made explicit to the students by their use of the form to self assess their performance, but they were also provided with a format with which to compare their progress against previous performances and a way to outline needs for improvement. The standard form provided a record of student learning and a guide for students to understand what was

expected of them, much in the same way a self-assessment rubric might do, by providing a description of what entails a quality product.

Likewise, Pengelly's (1988) study found samples of children's writing to be an invaluable record of student learning and development. Samples were kept and compared to each other as the year progressed, much in the way a mathematics portfolio (or journal entries) might be used to collect samples of formative work throughout the year. For the progress of learning in mathematics to be explicit, however, it is useful to be able to relate such samples to the achievement of specific learning outcomes or criteria for mathematical learning and thinking. There may be potential for assessment judgments arising from the analysis of such samples of student work, to contribute to a summarized record in the form of a chart that tracks student development along a seriated list of criteria, making progress throughout the year more explicit.

2.6 Using rubrics to assess student progress in learning

A rubric is an evaluative tool. It is an array of descriptions that define a continuum of product quality from very poor to very excellent (Hibbard, 1996). Rubrics may be task specific, used for scoring a single task, or they may be generic, for use in assessing the quality of various similar performances (Arter and McTighe, 2001). Generic rubrics are a particularly useful assessment (and teaching and learning) tool if the goal of the assessment is to teach students about the nature of quality, or to guide them in understanding what is expected of them in a given task or activity. Because the same generic rubric can be used to assess more than one task, they may assist students to generalise, to apply what they have learnt from one task to another. Generic rubrics can be used to encourage student self-assessment by asking them where their work fits along the continuum of quality, and to explain why they think it fits there. Students may also be encouraged to explain strategies they could employ to move future work up the continuum of quality.

While many prompts for writing can be pre-planned, many are, in fact, impromptu, provided or developed in response to activity in the classroom during a mathematics session (Miller, 1992a). This can make the development of generic rubrics challenging. On the other hand, a generic rubric can be developed to assess performance in more than one activity, without being applicable generically. Ciochine and Polivka (1997) developed a rubric used for both self and teacher assessment of expository writing assignments given to middle school students. This was a valuable and successful assessment tool, but was specific to the assignment type to which it was applied, not for expository writing in general.

Thompson, Thompson and Else (2000) suggest that journals provide a useful and simple record of student thinking that can also indicate student progress along a continuum of learning outcomes. Thompson et al. used the analysis of journal responses to assess children's conceptual level and to determine the effectiveness of planned activities to the desired mathematical learning outcomes. Their collation and analyses of journal entries from a year 1 and a year 2/3 class enabled the categorisation of responses into three groups:

1. Competent/Developed: able to effectively write about, and demonstrate the strategies used to solve a given problem, with a high level of accuracy
2. Developing: able to solve many of the given problems, although still with some mistakes, tends to identify materials rather than the strategies they used to solve a given problem, recounts actions rather than mathematical thought process
3. Not understanding: answers are inconsistent, incomplete or confused, with limited knowledge demonstrated about how to solve a given problem.

Greenwood (1993) suggests that all mathematics lessons could benefit by monitoring not only the content being studied, but also the actual growth in the student's ability to think and reason. How to monitor such growth in thinking and reasoning may be assisted by the use of writing journals and thinking based generic rubrics in mathematics. The three groups, or levels, defined by Thompson et al. (2000), after analyzing samples of student writing, enables

categorisation of student achievement along a continuum of progress that can be recorded as a cumulative profile. Such a record, if kept over time and across a variety of activities, may contribute to building a student profile of progress in mathematical achievement or learning.

2.7 Stimulating writing in mathematics

Stimulating communication in mathematics enhances understanding, and likewise, enhanced understanding stimulates communication in mathematics (Greenes, Schulman, & Spungin, 1992). To stimulate the need to describe, justify, explain and create, students need to be presented with problems that provoke curiosity. They need opportunities to share their thoughts, think about their ideas, receive feedback and adjust their thinking. The teacher needs to purposely orchestrate these opportunities (Greenes, et al., 1992, Bicknell, 1998).

Wadlington, Bitner, Partridge and Austin (1992) suggest a three-phase approach to stimulating writing in mathematics in elementary schools:

1. Write to communicate mathematics; this phase includes brainstorming to suggest ways that writing can be used in mathematics, completing a mathematics writing activity and sharing this with the class, and starting a journal writing programme to record mathematical ideas and observations.
2. Co-operative learning; at this stage students work in groups to complete a mathematical task. The students are required to record the task; its resolution, and their reflections regarding cooperative learning in their math journals.
3. Problem solving; students are prompted to apply mathematical thinking to every day problems. At this stage students are made more aware of strategy choices and alternative thinking. As in phase 2, students record the problem, strategies, resolution and their reflections in their mathematics journals.

Wadlington and colleagues found this three-phase process an effective way "to give students positive experiences in integrating written communication of

mathematics and cooperative problem solving" (p. 209). They also observed that as students continued to write regularly they became more reflective, expressive mathematicians, able to view problem solving as a creative, rewarding activity. Students who write regularly develop skills in communicating their mathematical ideas. The quality of their writing improves with practice. By becoming more reflective, creative and expressive, students develop a wider range of genre in their mathematical writing.

2.8 Mathematical genre

There are a number of mathematical genres or writing styles (Marks & Mousley, 1990). These include:

- Narrative: events recounted - simple, generally past tense, a recollection of events
- Procedural: methods described - how something is done
- Description and report: nature of individual things and classes of things- what something is like
- Explanatory: judgments outlined - reasons why a judgment has been made
- Expository: arguments developed - why a thesis has been developed.

To be mathematically literate, students need to be exposed to, and encouraged to use, as many of these genre as possible when writing in mathematics.

Marks and Mousley (1990), discovered in an examination of primary and secondary mathematics classes and commonly used textbooks, that the narrative recount genre dominated. Many other genres were found to be entirely absent. Such genre exposure, Marks and Mousley suggest, is both limited and limiting. Rarely seen or absent genre were in fact the ones that exposed the thinking and understanding of the writer most explicitly. Marks and Mousley therefore suggest "teachers should broaden their scope of task specification so that a wider range of mathematical genres is experienced in classrooms" (p 117).

Students can be made aware of the use and applications of each genre, from a very early age, through modeling and guided construction, across a variety of situations. Pengelly (1988) states that given time and practice, children's mathematical writing does develop in sophistication. The implementation of a journal writing programme may go some way to providing opportunity for the teacher to model a variety of mathematical genre, and for the students to practice using them, in response to a wide variety of stimulating prompts.

Mitchell and Rawson (2000) observed that even well balanced written texts, that supply teachers with support material designed to focus attention on student thinking, generally fail to challenge children to explain or justify their thinking; "There is no firm evidence that teachers make use of such guidance, particularly if they are monitoring a large class all working at their own pace on individual tasks" (p. 183). In response to this observation, Mitchell and Rawson initiated a set of frames to support primary school children's mathematical writing, with a particular emphasis on extending children's explanations and reasoning skills in ways that traditional, more fictional-based writing programmes in primary schools have not. These frames prompted and guided students to write by providing the start of sentences that needed to be finished. For example, a 'proof' frame for investigations might include the following prompts:

- My task is to.....
- I think that.....
- One reason for thinking that is.....
- Another reason is.....

These frames covered the six genres identified by Mitchell and Rawson in mathematics:

- Report: - a non-chronological description
- Recount: - retelling events in chronological order
- Enquiry: - establishes a way of working through a problem
- Explanation: - logical steps that inform how or why something works
- Proof: - gives evidence of some sort and draws logical conclusions from

that evidence

- Planning: - information on how to tackle a particular investigation.

While time consuming to establish, these frames were found to provide a common focus for both the teacher and students, to force awareness of the nature of mathematical explanation. Using these frames enabled the students to concentrate on their thinking and provided structure for that thinking by guiding them through the process of recording ideas. At the same time, the teachers were provided with a framework against which to scaffold student learning and eventually assess student progress in thinking and understanding. Ultimately, however, these frames were designed to be temporary; to be removed and replaced as students develop competence and confidence in writing their mathematical ideas.

Clarke, Waywood and Stephens (1993) analysed the journal writing of 500 grade 7 students. From this, they were able to suggest a relationship between students' mathematical writings and their perceptions of mathematics and mathematical activity. Clarke and colleagues were able to identify a progression of three modes of writing in journal entries:

1. Recount: basic, shallow descriptions of what the student did
2. Summary: includes more detail of what the student did and the beginnings of identifying problems of their own learning and descriptions of how they achieved a solution
3. Dialogue: a focus on the ideas being presented, the student begins to "relate the mathematics being taught to what they are learning and [is beginning to] connect new ideas with what they already know" (p. 248).

This progression tends to follow a rubric formation demonstrating a shift through the summary mode "in which the focus is the compilation of cognitive knowledge and skills to the dialogue mode involving the acquisition and utilization of metacognitive skills" (p 248). The assumption is that as students' skills in explaining and justifying improve, they move through these three modes of writing. These researchers contend that the key to progression through the modes of writing "appears to be to encourage students to question

themselves when they do not understand rather than be dependent upon their teacher to tell them whether they understood" (p. 248), that is, to engage student thinking and self assessment. In this sense there is potential for a simple record to be kept of student progress. Such a record may, particularly if it is in rubric form, provide both the teacher and the students with a guide for developing skills in communicating mathematical ideas, and developing a wide range of mathematical genre.

Davison and Pearce (1988) suggest that, "performing a writing task requires students to reflect on, analyse and synthesize the material being studied in a thoughtful and precise way" (p. 42). They provided suggestions for the following writing activities as positive ways to reinforce mathematics instruction:

- Direct use of language; copying and recording information
- Linguistic translation; the translation of mathematical symbols into written language
- Summarising; paraphrasing or summarising given material, generalising, drawing conclusions
- Applied use of language; application of a mathematical idea to a problem situation
- Creative use of language; using written language containing mathematical concepts, to explore and convey information but not specifically being studies in mathematics.

The analysis of student writing is complicated, there is an ever increasing list of descriptions of what constitutes mathematical writing. Shield (1995) identified a list of six elaborations in student writing giving them names to enable consistent description by both student and teacher (Shield, 1995, p. 38)

- *Nucleus:* definition or general statement of procedure
- *Goal:* statement identifying the concept or procedure being explained

- *Demonstration:* worked example of the concept or procedure elaborated with a) symbolic representation b) verbal description c) diagrammatic representation d) statement of convention
- *Justification:* statement justifying parts of the procedure in terms of known ideas
- *Link:* reference to prior knowledge of everyday experience
- *Practice:* exercises to be attempted by the reader by modeling on the demonstration

This coding assisted the analysis of the writing style of middle grade students (Shield & Galbraith, 1998), but may be somewhat overstated for the purposes of assessing the journal entries of elementary school children.

While journal writing does provide students with an opportunity to express ideas and develop the concept of writing in mathematics, it is not a total writing programme. It may not always be necessary for students to write pieces in these journals of a high-level, sophisticated nature. Encouraging students to write high level, sophisticated pieces may be an end goal of a writing programme in mathematics, but we must also value the simple pieces of writing for their usefulness in diagnosing difficulties, misconceptions and attitudes. It may be enough for students, on occasion, to write an idea, a thought or an opinion. Assessment of student journal entries and the contribution of this assessment to a record of progress in learning and communication of mathematics needs to be quick, easy and consistent. A long, complicated analysis of journal entries is not a viable assessment technique and not likely to be adopted by already busy teachers.

2.9 Benefits of regular writing in mathematics

Brenda Bicknell, in her 1998 thesis, (The writing of explanations and justifications in mathematics) states from her research findings, that

> "unless, and until, explanations and justifications become a regular feature of the mathematics classroom, it is unlikely that students will spontaneously and confidently engage in such activity even

> when it is appropriate to do so. Students need to be given opportunities to develop an understanding of what makes a quality explanation.....Essentially, students must be challenged to fully engage in making mathematical sense by writing explanations and justifications" (p. 125 -126).

Bicknell's findings support the implementation of regular discussion and writing of explanations and justifications both within the classroom mathematics programme, and within a range of assessments. In order to maximise the learning opportunities of this mathematical discourse, students need to be given time and opportunity to practice, develop and perfect their skills and confidence in writing and communicating in mathematics. They also need guidance in understanding what defines a quality explanation. Carefully formulated rubrics that encourage students to evaluate their own work, and to fit it into a continuum of quality, may go someway to achieving this.

Most writing in mathematics takes the form of either journal writing or expository writing (Shield & Galbraith, 1998) and should be beneficial to both the student and the teacher.

Benefits to the student

Di Pillo, Sovchik and Moss (1997) suggest that writing directs the student to think about their thinking, to slow down, organise, focus and clarify their thinking. Likewise, McIntosh (1988) contends that writing gives students the freedom to express ideas and develop as individuals. A greater emphasis of the writing process in mathematics

> "might contribute to improving the attitude of girls to [mathematics] because (a) there was a greater emphasis on language and (b) most primary and early childhood teachers are female and their strengths are more often in the language areas than in mathematics...a corresponding improvement in their own attitude to the subject...could be communicated to their students, particularly the girls" (p. 22).

Writing in mathematics also helps students to develop their communication and reasoning abilities (Bicknell, 1998, Ciochine & Polivka, 1997). By having to write explanations and justifications, a student is required to consider what they mean when they write, to question their understanding and to reflect on their learning. Writing in mathematics ultimately develops in students the ability to apply deep and well-structured strategies to mathematics in a meaningful way, empowering students to relate thoughtfully and therefore, meaningfully to mathematics in general (Ciochine & Polivka, 1997).

Pengelly (1988) undertook a study of early elementary children as they explored number and numeracy. She advocates the use of manipulatives to enable students to develop for themselves a deep understanding of number. However, she found that a large gap existed between what children were able to demonstrate with the concrete manipulation of materials and their use of symbols to represent ideas effectively in mathematics. Pengelly (1988) suggests that the added process of recording mathematical experiences helps to bridge this gap. Over time, with practice and guidance, Pengelly observed that these written records developed in stages:

- *Descriptive*- story like
- Becoming more *abstract*
- Becoming more *symbolic*

This development in the children's written records demonstrates a development in sophistication of writing that either moves to a higher level of the original genre or in fact moves into different genre of mathematical writing.

Additionally, writing in mathematics has been found to assist ESL (English as a Second Language) students to develop their understanding of mathematics in both their native language and in English. Wilde (1991) advocates ESL students writing in their own language first and translating later into English their mathematical thinking when they are ready, with or without assistance as required. In discussing the value of journal writing to ESL students, Wilde

explains that journal writing is an opportunity for ESL students to have space and time to think at their own pace, and privacy in which to express their thinking. Moreover, Wilde argues that ESL students who write regularly in journals, are likely to develop a deeper understanding of mathematical terms in both their first and second languages.

Benefits to the teacher

The most obvious benefit of student journal writing for the teacher is the opportunity to assess students' understanding and disposition. Through student writing, "inaccurate conceptual and procedural thinking can be observed and corrected... student attitudes about mathematics can be noted and, if needed, modified" (Di Pillo et al., 1997, p. 308).

In Pengelly's study (1988) the use and understanding of abstract symbols was an outcome of the process of representing ideas in a written form. The writing and recording process became a teaching and learning tool. Through this recording process the child's understanding of a process or concept was exposed and the samples of writing proved to be an invaluable record of student learning and development.

For Jennifer Mayer (Mayer & Hillman, 1996), a high school mathematics teacher in USA, writing plays an important role in mathematics. This teacher has 130 students and finds she is better able to get to know her students through their writing than through traditional mathematics activities or discussions. Mayer states that it is not possible to individually interview 130 students, but that by reading and responding to their writing she is better able to develop a rapport with her students and therefore, to assess and understand her students as individuals. Thinking not previously immediately evident in other forms of assessment is exposed through students writing in the forms of journals, laboratory reports and portfolios. Specifically, Mayer uses student writing to pinpoint misconceptions, monitor progress and to expose gaps in her instruction. She contends that student writing is a reliable source of information on what students know and what they can do.

2.10 Influencing change in student attitude towards writing in mathematics

Liedtke and Sales (2001) observed that many students, by the end of elementary school, did not see writing as an important part of mathematics learning. They initiated a project that exposed a group of seventh grade students to a wide variety of writing tasks. With the use of a before and after, true/false survey the researchers were able to assess a change in attitude of the students towards the value of writing in mathematics. They observed students being prompted to write creatively about open-ended mathematics tasks. While these tasks were matched to prescribed learning outcomes, they stimulated thinking beyond the standard mathematics activity, and focused student attention on their own thinking and learning. These open-ended prompts to write required more from the students than the mere recording of actions or knowledge, but rather, that they explore ideas and justify solutions. In addition to greater student participation in their own mathematical learning, the outcome of the survey carried out after students experienced writing in response to open-ended prompts, also indicated a significantly more positive attitude of the students towards the role and value of writing in mathematics.

2.11 What is a writing journal?

Generally, a writing journal in mathematics is an exercise book in which students write about mathematics. Journal writing may take place daily or weekly but does need to occur regularly as part of the regular mathematics programme. Students write in these journals, generally in response to prompts, but sometimes in a free writing time, either before, during or at the end of a regular mathematics session. Teachers then read the students journal entries and respond, usually in writing in the journals themselves, for the students to read and possibly respond to further. Journal writing time may include a sharing session, in which either the teacher models mathematical thinking, or students share their mathematical ideas as written in their journals, with their peers. An excellent overview of mathematics journals and their

implementation is provided by the web site www.ucs.mun.ca/~mathed/t/rc/jour/journal.htm

2.12 Prompts for journal writing in mathematics

To initiate journal writing, Diane Miller (1992a) suggests the use of prompts, both planned and impromptu (i.e. prompts resulting from activity in class). A prompt might be a question, a direction, an unfinished sentence or some statement that the students are asked to comment on. They are given to the students in either written or oral form with the aim of stimulating writing. Carefully worded prompts may direct students to write within a particular genre or expose ideas and thinking previously not easily available to the classroom teacher. Planned prompts provide an opportunity for the teacher to assess student understanding or interpretation of pre-planned learning outcomes. Impromptu prompts may provide the teacher (and students) with information about the effectiveness of a given lesson.

Di Pillo et al. (1996) initiated a collaborative project, involving two teachers, designed to:

1. Examine the mathematical thinking and disposition of a group of middle grade students (26 fifth graders and 28 sixth graders)
2. Explore the participating teachers' perceptions of, and reactions to, the student writing experience.

The project took place over an eight week period, and involved the students writing in their journals, three or four times a week, for five to eight minutes each time, in response to specific prompts. The teachers, in the form of written comments, questions, or encouragement, responded to these journal entries individually. Writing prompts were jointly developed between teachers and researchers across four categories:

- Instructional: prompts pertaining to concepts or procedures being studied by the students
- Contextual: prompts asking children to communicate dispositions or attitudes

- Reflective: prompts asking students to think back in time or place and reconstruct an event
- Miscellaneous: prompts combining affective questions with mathematical applications to daily life.

Di Pillo and colleagues found that, by using the full range of prompts to stimulate journal writing, teachers were able to gain insights into students' conceptual and procedural knowledge, their attitudes and feelings about mathematics, their perception of instruction and their views about real-world applications of mathematics. Students were stimulated to practice writing in a variety of genre. When asked for feedback, these students suggested that journal writing was an effective way to communicate with their teacher and may facilitate retention of mathematical learning.

Gordon and MacInnis (1993), in their study of 180 grade 4-6 students use of journals in mathematics, reported the benefits of both writing to a given prompt and free writing. Free writing time was given at the usual journal writing period, but instead of providing the students with a prompt to respond to, they were encouraged to write on any aspect of mathematics the students felt inclined to write about. Gordon and MacInnis found that while initially students found it difficult to write in these free sessions, eventually, given time, modeling and reinforcement (particularly in the form of written responses from the teacher) students were able to expose previously hidden aspects of their attitude and thinking. To initiate prompts, Gordon and MacInnis used the curriculum guide for mathematics from their province, which stipulated objectives in numeration and operations. This relatively limited approach to the development of prompts may account for their finding that prompted journal writing generally only exposed information as to their students' conceptual or procedural knowledge.

2.13 Benefits of regular journal writing in the mathematics classroom

The flow of communication has historically been unbalanced with the bulk flowing from teacher to student. Marks and Mousley (1990), suggest that

encouraging student journal writing increases the flow of communication from student to teacher and exposes previously hidden information about student understanding and attitudes in mathematics. By giving constant feedback in the form of written or verbal comments in response to journal entries, students have their voice recognised. This constant feedback has been shown to be highly motivational in students, encouraging greater communication in mathematics in general (Gordon & MacInnis, 1993, McIntosh, 1991).

L. Diane Miller is a strong advocate for writing journals in mathematics. She has written extensively on journal writing in secondary schools (1990, 1992a, 1992b, 1993). Miller (1992b) claims that writing in journals in response to prompts can be an effective management tool. She suggests that journal writing can be an effective and useful way to begin a math class, with the added advantage of being a quiet and settled way to begin learning, giving students and teacher time to prepare mentally for the upcoming lesson. Additionally, Miller (1992a) has found in her research that instructional practices are often influenced as a result of teachers reading and responding to students' journal entries.

Writing journals in mathematics can be an effective teaching tool. Through their own writing, and in their responses to students' journal entries, teachers are provided with an opportunity to model good thinking and strategy use (Ciochine & Polivka, 1997, Schoenfeld, 1994). Modeling through writing in mathematics, provides teachers with an opportunity to develop a wider variety of mathematical genre for their students in contrast to the dominantly narrative/recount genre of mathematics textbook writing. Shield (Shield, 1995, Shield & Galbraith, 1998) suggests that middle school students previously unused to writing in mathematics tend to mimic textbook writing, the only form of mathematical writing they might regularly be exposed to, limiting their opportunity of developing their own thinking or exposing their own understanding of mathematics. Teachers must model thoughtful writing in mathematics if they expect their students to produce the same. There is also

opportunity for affective modeling in the sharing of student journal entries, using examples of peer writing to expose students to a wider variety of mathematical thinking, ideas and genre.

As an effective learning tool, journal writing can assist in the development of skills for proof, a central aspect of mathematical thinking. Children tend to believe that which they can themselves prove (Porteous, 1990). Journal writing aids students in their development of proofs in mathematics in several ways:

- It forces them to slow down and clarify their thinking,
- It gives their ideas voice, and
- It promotes an attitude in students that they are expected to be able to explain their thinking and to justify their ideas.

It is not possible to individually interview all students as to their understanding of a given concept or mathematical process, all of the time. And full class, or even small group, discussions have always the potential of expressing the ideas of only a few students (Mayer & Hillman, 1996). As an assessment tool, individual, privately written journals provide an opportunity to reveal student thoughts and ideas previously unavailable to the classroom teacher. The teacher is better able to get to know students individually and to recognise their specific problems, difficulties and strengths (Marwine, 1989, Mayer & Hillman, 1996). A consequence of this knowledge of students' individual thinking and understanding, is to enable the teacher to respond to individual needs (Borasi & Rose, 1989).

Davison and Pearce (1988) suggest that journal writing provides an opportunity for students to expose misconceptions that may otherwise be masked by mathematical performance in more traditional mathematical activities. In such instances, "the correctness or incorrectness of a response can only be interpreted if a teacher has some insight into the child's thinking and reasoning" (Sgroi et al., 1995, p. 275).

Journal writing can also be an effective method of gathering information about student disposition to mathematics:

> "Journals that exhibit a tendency to reflect and a willingness to explore alternatives, as well as confidence in the subject matter, perseverance through a challenge, and interest that is sustained over time, are typical of students with positive dispositions" (Bagley & Gallenberger, 1992, p. 660).

"The more the students use their journals to write expressively, i.e. as a place where they can think on paper and not just report already formed ideas, the more they will exploit the potential of writing as a tool for learning and growth" (Borasi & Rose, 1989, p. 364). Writing journals provide opportunities for the teacher to gain insight into attitude, strategies and problem solving techniques in an ongoing, relevant way, and for students to develop mathematical skills.

2.14 Methods of assessing mathematics through journal writing

Writing forms only a part of assessment in mathematics (Wilde, 1991) and journal writing only a part of that. However, the unique nature of journal writing has much potential as an assessment tool. It is not possible for a teacher to read a student's journal entry without making some form of assessment judgment, be it of the student's understanding or of the effectiveness of the teaching (Bagley & Gallenberger, 1992).

Thompson et al. (2000) found, in their analyses of journal writing, that aspects of their students' mathematical understanding they had not previously considered were exposed and able to be assessed. Over time, students learn how to communicate clearly and effectively their mathematical ideas and attitudes. In order to make journal writing more effective as an assessment tool, Thompson and colleagues provide the following suggestions:

- Allow for discussion time prior to writing
- Model journal writing

- Experiment with alternative forms of journal writing to include pictorial, scribed and diagrammatic recording
- Allow sufficient time and opportunities for student writing
- Be aware of student's language development
- Allow children opportunities to share, discuss and reflect in their journal writing
- Move from simple to more complex journal writing tasks.

The use of writing journals in mathematics as part of the overall mathematics programme effectively integrates mathematical activity (journal writing) with assessment. The unique nature of these individually written journals provides a record of evidence of student development, enabling the teacher to evaluate growth in learning (Borasi & Rose, 1989).

Sgroi et al. (1995) suggest that the mathematics experience of the child is profoundly affected by assessment using journals. How the teacher responds to a student's journal entry provides feedback to the student about teacher attitude and beliefs as well as providing further information about how the student is doing in mathematics, and what they need to do next to improve further.

Some researchers note that the journals themselves can be used to provide a record of student progress (Gordon & MacInnis, 1993) and that it is enough to use journal entries to affect short term planning and as samples of thinking, learning and understanding for comparison throughout the year. Other researchers have begun looking at the opportunity of using generic rubrics to summarise student progress and achievement, as exposed through their journal writing, along a continuum of learning outcomes (Thompson et al., 2000). These generic rubrics may provide students and teachers with clear guidelines that assist them in developing skills in explaining and justifying their mathematical thinking, involving students in the self evaluation of their own mathematical learning.

2.15 Summary

Journal writing in mathematics provides a valuable opportunity to promote skills in explaining and justifying mathematical thinking, and to develop skills in communication, in line with contemporary mathematics curriculum guidelines. Writing requires students to think about their own thinking and learning, to slow down their thinking, to explain their actions and to justify their solutions. Students are able to develop ideas at their own pace and to expose thinking and attitudes previously hidden from their teachers. Through journal writing, students are given the opportunity to communicate privately with their teacher.

Journals provide teachers with the opportunity to both assess the effectiveness of their teaching programmes and the level of their students' understanding in mathematics. Teachers are able to communicate with their students through writing journals. They are able to 'listen' to the thinking of all of their students individually and frequently, and to respond appropriately to their students' individual needs in mathematics.

Writing journals have been found to provide a record of student thinking in mathematics. There may also be potential for journal entries to contribute clearly, efficiently and formally to an overall profile of student progress in thinking, learning and achievement in relation to specific learning outcomes through the use of generic rubrics. It may be possible to use Greenwood's (1993) criteria for mathematical thinking to prompt and guide student journal writing and to use thinking based rubrics to guide students in understanding what defines, and how to achieve, a quality explanation or justification in mathematics.

Chapter 3

Methodology

3.1 Introduction

This research project was undertaken in a naturalistic setting, in collaboration with a teacher who aimed to improve her teaching practice. Whilst the researcher initiated the project, specific research objectives were strongly influenced by the needs and input of the teacher who shared ownership of the project. Outcomes were determined largely by the teacher's needs, rather than preconceived by the researcher.

In planning this research project, an Action Research approach was adopted. This included 2 diagnostic stages and 3 cycles. The research took place in a single grade three class, within an international school in China, and focused on the pedagogical practices of an individual teacher.

3.2 Action Research

This research project followed the design of action research. Action research is not a method or a specific technique. It is an approach (Bell, 1993).

What is Action Research?

Action Research is generally undertaken by people who want to do something to improve their own situation (Sagor, 1992). "The fundamental aim of action research is to improve practice rather than to produce knowledge" (Elliot, 1991, p49). While no two approaches to action research are exactly the same (Sagor, 1992), there are several consistencies to definitions offered by various authors on the matter (e.g. Burns, 1997, Elliot, 1991, McKernan, 1991). Generally, action research aims to answer specific questions within the context of a particular situation. It is a voluntary collaboration between professionals (in this case researcher and teacher) to define or diagnose a problem, to

remediate action towards finding solutions to that problem and to evaluate the outcomes of the remediation. Action research is cyclic in nature, generally following a plan-implement-evaluate type cycle several times until ultimately, a suitable solution to the defined problem is suggested.

Social psychologist Kurt Lewin was the first to coin the term *action research* (Burns, 1997, Elliot, 1991). He suggested that such research starts with a diagnostic stage, beginning with fact finding around an initial idea and resulting in a plan for research or data gathering. The research then moves into a therapeutic stage in which the plan is implemented, monitored and evaluated. The evaluations lead to an amended plan that is again implemented, monitored and evaluated. This cycle or spiral continues within a naturalistic setting, until a suitable solution is found. Lewin's model has provided a base to a variety of similar models (see McKernan, 1991), being adapted, in true action research form, to meet the specific needs of the type of research topic under study.

Why Action Research methodology was appropriate for this study

Among a range of uses for action research, Burns (1997) lists:

- To remedy problems specific to a given situation
- As in-service training
- To innovate and expand existing teaching and learning.

In this project, the teacher had specifically asked the researcher for guidance and assistance in developing her mathematics programme. The teacher had asked the researcher to help her to expand her mathematics programme, to bring it more in line with the reflective nature of the rest of her teaching practice, and to supplement, without replacing, her textbook based mathematics programme. She wanted assistance in developing her assessment of her students in mathematics, to incorporate self-assessment procedures in line with her assessment procedures in other areas of the curriculum.

The responsive nature of action research to the actual classroom needs within a naturalistic setting enabled us to change focus as the study progressed, adapting to the needs of the teacher and her class. In the process of finding a solution to her problem, we were able to innovate and expand upon the teacher's own existing teaching methods. We used action research to promote teacher self-improvement (Burns, 1997). Mrs. J contributed her own specific strengths to the project in collaboration with myself as research supervisor. The action research model was felt to be especially suitable for encouraging teacher reflection that would be sustainable even after the research project per se had finished.

3.3 Design of this study

The design of this study included 2 diagnostic sessions and 3 therapeutic cycles; each informed by reflective feedback. Following is an overview of the broad stages and cycles of this research project:

Initial interview:

- To establish and refine our research question
- To list the needs and roles of the teacher and the researcher
- To outline suggestions of ways in which these needs might best be met.

Pre-project:

- To share information between teacher and researcher about our research topic, namely journal writing in mathematics
- To share our expectations for the project
- To further discuss needs and roles of the teacher and researcher
- To prepare a 'starter kit' of prompt ideas to initiate student journal writing.

Cycle 1:

- To introduce the concept of journal writing to the students
- To trial a range of approaches and prompts

- To observe student and teacher reactions to the journal writing programme.

Cycle 2:

- To evaluate the students' responses to journal writing in mathematics
- To evaluate the type and value of the writing students produced and its contribution to the mathematics programme and the teacher's understanding of student learning
- To modify prompts in order to improve the quality and value of student journal writing.

Cycle 3:

- To evaluate the impact of the cycle 2 modifications on the type, quality and value of student journal writing
- To encourage the teacher to take ownership of the journal writing programme as much as possible, to meet her need to better understand her students' learning in mathematics
- To explore the impact of journal writing on the teacher's overall approach to mathematics teaching
- To explore the impact of journal writing on the teacher's assessment of her students in mathematics.

3.4 Setting of the study

The teacher-: Mrs. J

There is value in focusing research on a specific teaching style as a contribution to an overall picture of how individual teachers can use journals in mathematics (Borasi & Rose, 1989). The teacher involved in this study is highly competent and runs an inquiry-based programme in every area of the curriculum other than mathematics. She has stated a lack of confidence in teaching mathematics and admits to relying on the textbook for her whole class mathematics programme. Self-reports indicated that Mrs. J is concerned

about how to help lower ability and ESL students and about assessment of individual students in mathematics.

Mrs. J is a team leader for the grade 2/3 (Y3/4) syndicate and mentor to other teachers in the team. She is involved in curriculum development at a school-wide level and assists in training staff in student led assessment. In every area of the curriculum, other than mathematics, Mrs. J involves her students in goal setting and self-evaluation, with clear learning objectives focused on the individual development and achievement of each student. In contrast, her mathematics programme is textbook based and teacher directed with little provision for individual needs or student involvement in assessment. She states that her assessment of students in mathematics is largely by 'professional judgment', through observing individuals as they work on class activities and through helping those who get stuck. She keeps no written record of these observations. Samples of student work are stored in individual portfolios, one piece for each topic and a list of answers to a basic facts 'test' each term. These samples are teacher selected, generally produced for the specific purpose of inclusion in the portfolio, and are not accompanied by any explanation of learning outcomes, learning behaviors or criteria for assessment.

Ability grouping had been trialed at the start of the year but Mrs. J had found group teaching in mathematics difficult to manage. Overall, Mrs. J felt she lacked depth in her understanding of mathematics and struggled to initiate effective learning activities for students not involved in the group working with the teacher.

Mrs. J is intrinsically motivated to change by her recognition of a need to learn more about her students' learning of mathematics, and by a desire to bring her teaching and assessment of mathematics in line with her teaching and assessment of the rest of the curriculum. At the same time, she is experiencing extrinsic motivation to change her teaching and assessment of

mathematics as the existing mathematics curriculum for the school is in the process of being rewritten for implementation the following year. This teacher wishes to bring her teaching and assessment of mathematics in line with the rest of her programme, in which student learning is the focus.

The school

The school in which this study takes place is an international school in the process of implementing the International Baccalaureate, Primary Years Programme (PYP). This programme is developed, promoted and overseen by the International Baccalaureate Organisation. Historically, the school in which this study takes place has depended upon a textbook based approach to mathematics. A standard text is assigned to each level and teachers are expected to work within and around that text. The school mathematics curriculum is in the process of reform in an effort to match the objectives of the PYP. There is general support among the staff for the philosophy and objectives of the PYP but a concern for the lack of specific programme content, in mathematics in particular. There is a strong feeling among the staff that textbooks will remain a central feature of the majority of the classroom mathematics programmes. They feel that the textbooks may provide the solid content that the PYP appears at this stage to lack.

Primary Years Programme (PYP) "describes the taught curriculum as the written curriculum in action" and is "an international curriculum framework designed for all children between the ages of 3 and 12 years...[It] provides an internationally designed model for concurrency in learning and incorporates guidelines on student learning styles, teaching methodologies and assessment strategies" (Primary Years Programme Assessment Handbook, 2001, p2). Specifically, the PYP encourages integration of assessment into the everyday programme and insists that the students' learning is the focus of assessment, rather than standardised criteria. The PYP assessment guidelines state that assessment should identify what students know, understand, can do, and feel at different stages in the learning process. These guidelines encourage a

range of assessment methods "to build a balanced view of the child" (p7). Suggested methods include:

- Observations
- Performance assessments
- Process-focused assessments
- Selected responses
- Open-ended tasks
- Portfolios.

Open-ended tasks are defined as "situations in which children are presented with a stimulus and asked to communicate an original response" (p7). Students are expected to be able to communicate mathematical thinking and ideas both verbally and in a written or recorded form. At the culmination of the PYP experience (in grade 5, year 6), students produce a multi-disciplinary personal inquiry project. There is no specific mention in the PYP documents that suggests the implementation of writing journals in mathematics, or the implementation of any regular writing in mathematics. There is, however, a need for students involved in a PYP mathematics programme to practice and develop their communication skills in mathematics. Both the teacher and researcher in this project anticipated that the implementation of a journal writing programme in mathematics would go some way towards meeting this goal.

3.5 Population and sample

This project took place in a relatively new international school in China; it had been open for five years. To attend an international school, the Chinese government specifies that at least one parent of a student must hold a foreign passport.

The school maintains a role of around 550 students throughout the year from 42 different nationalities. The youngest students are in nursery, aged 3, and the oldest in grade 8, aged 13-14. In the research project year, there was a 45 strong faculty of fulltime teaching staff and various support staff. Class sizes

were maintained at a maximum of 21 and students received specialist tuition in computers, languages, art, physical education and music.

The grade three class in which this research project took place had 20 children (10 girls, 10 boys), aged eight turning nine. These students represented twelve nationalities. Eleven spoke a language other than English as a first language in the home. Four of these students were diagnosed ESL*, requiring daily lessons and extensive support in developing oral English. A further three students received daily lessons in written English (ELE, English Language Enrichment). By the time this research project entered the classroom, the academic year was approximately half way through. All four ESL students could communicate adequately in oral English and were confident enough to attempt writing in English (two of these students communicated very effectively in written English). The three ELE students readily recorded ideas in English. Both ESL and ELE students chose to write primarily in English in the classroom. Two of the ESL students were Finnish girls who regularly discussed classroom matters in Finnish before jointly translating their ideas into either oral or written English.

Drawing from an international expatriate community, the range of intelligence and general ability was positively skewed, with only 1 student requiring remedial tuition. Most students lived in a complete nuclear family, in which the father worked and the mother stayed home.

3.6 Ethics

The participating teacher's involvement in this project was voluntary. She understood that she was able to withdraw from the project at anytime, and in deed, on several occasions, the project was adapted and adjusted to meet her needs and those of her students.

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* English as a Second Language students who speak a first language other than English

Written permission was attained from the school director, elementary school principal, mathematics department leader and the participating teacher to undertake this research project. Specifically, permission was sought to:

- Work inside a particular classroom, with the voluntary co-operation of the teacher
- Gather samples of student writing
- Access data of student assessment in mathematics
- Informally interview students about their writing, if necessary, in a way that would not interfere with their learning
- Record findings of the research in the form of a thesis, in a way that protected the privacy of those involved
- Seek permission from the parents of the students involved in the project.

Assurances were given that:

- Privacy would be respected and protected to the best of the researcher's ability
- The research would not unduly interfere with the existing classroom mathematics programme.

Once this permission was received, a letter went home to the parents of students outlining the proposed research project and the anticipated role of the students, teacher and researcher. Permission was sought from the parents to:

- Collect samples of student's mathematics journal writing
- Access student assessments in mathematics
- Informally interview students about their mathematics journal writing.

Assurances were given that:

- A student may refuse to answer any questions and may withdraw from the project at any time
- Participation in this project would not impact on a student's ability to participate in the normal classroom programme
- Each students privacy and anonymity would be protected to the best of the researcher's ability.

3.7 Techniques for gathering data

A detailed diary was kept by the researcher recording observations, dialogue, thoughts and suggestions for follow up sessions. This served as a record or log of professional activities (Bell, 1993). The teacher, as suggested by the researcher, attempted to keep a diary recording writing prompts, observations and reactions to particular sessions. However she found this too time consuming to maintain and ceased to record in her diary after only two sessions.

Interviews between researcher and teacher were undertaken. Extensive notes were kept during these interviews. While these interviews were carefully planned, they were generally informal. Initial and early interviews took the form of sharing and probing for information, followed by co-operative planning for future mathematics sessions and journal writing prompts. The final interview was more formal and was structured around a pre-set list of questions.

Samples of student work and assessment material were copied and kept. These included:

- Journal entries and teacher responses to those entries
- The teacher's journal checklists
- Assessment rubrics
- Assessment feedback sheets
- Portfolio entries.

3.8 Reliability and validity

Action research, by its very nature, is truly only valid for the specific situation in which it was carried out (McLean, 1995). In this case, findings are specific to the individual teacher with whom the researcher worked. Findings may be generalised to other situations, but as McLean (1995) suggests, action research "is like test driving an automobile before we purchase it " (p45). Each individual 'purchaser' will base their decision to 'buy' upon their own personal

circumstances, with different 'models' impacting differently on various people. This project has been a test drive for the teacher involved. However, as a team leader for the grade 2/3 syndicate, she will inevitably share her findings from the project with others in the team. Whether or not these findings prove to be valid for others in the team remains to be seen. It is most likely, however, that this 'test drive' will make the implementation of journal writing in mathematics a smoother drive for others in the team.

3.9 Assumptions and limitations

This was a collaborative research project involving the teacher and myself as researcher. We shared common interests and we worked together to investigate issues related to those interests (Sagor, 1992). This was a fluid partnership of mutual respect with the specific purpose in mind of finding a solution to the research questions derived from my personal interests and the teacher's classroom/pedagogical priorities.

However, the teacher and I did not approach the project equally. Whilst I have a teaching background and had experience teaching along side this particular teacher in the past, we came together at this time in collaboration to share our expertise: I brought to this collaboration a knowledge of contemporary research of student writing in mathematics, and journal writing in particular, and the assessment of mathematics. The teacher brought a wealth of teaching experience, a working knowledge of assessment across the curriculum and a knowledge of her students. My area of interest and expertise was in mathematics education, which was at the same time, the teacher's perceived area of weakness. Mrs. J's perception of my role was more than that of researcher. I was also to be an advisor and mentor. As time progressed and we moved through the cycles of the research, the teacher's level of interest, confidence and expertise developed. My role of advisor and mentor diminished and I became eventually, almost solely a researcher.

This research took place in the naturalistic setting of a working classroom with all the practical restrictions this entails. There were times when planned research sessions had to be rescheduled or cancelled. Time was limited and further pressurised by the fact that the school was set in the northern hemisphere, meaning that the school year finished at the end of June. As I was working within the time frame of a southern hemisphere masters programme, the time in which research data could be gathered was condensed. Because of this time pressure, the third and final cycle of the research was affected. It had to take place towards the end of the academic year, when other priorities for the teacher's time and concentration took precedence over the research project. As a consequence, this cycle was somewhat restricted and the resulting data less than anticipated. However, the teacher was, by this stage, very involved in the project, conceptually and practically, and was still able to provide useful feedback and insights.

Whilst the use of writing journals in mathematics aims to focus attention on individual students, the focus of this study was, in fact, the pedagogical practices of the teacher. This included a focus on the impact of student journal writing on this teacher's approach to mathematics, on her mathematics programme in general and on her assessment of students in mathematics. As action research, it aimed to answer questions specific to an individual teacher, within a particular international school setting. Whilst this project does not aim to obtain scientific knowledge that can be generalised, it is possible that what is learned here may be of use to others in a similar context.

3.10 Summary

This research project followed an action research approach. It grew out of the interests of the researcher and from the needs of a particular teacher to improve her teaching practices in mathematics. The responsive nature of action research enabled this project to develop in response to the feedback from, and within the confines of, a naturalistic setting.

Chapter 4

Results

4.1 Overview

As action research, this project developed as it proceeded. The development of ideas, the adaptation of the programme to the developing needs of the students and the teacher, and the progress of change, are reflective of the nature of this project. Because of this, this chapter is written in diary form, along a time line of events and developments.

We started with the goal of implementing a journal writing programme, using thinking criteria as a guide for the development of this programme. I will begin with a description of the two initial planning sessions that were instrumental in determining the direction of this research. I will then give details of each of the three cycles as they developed, describing how the project developed beyond the initial goal, to incorporate assessment procedures initiated by the teacher to enable her to bring her assessment of mathematics more inline with her assessment of other areas of the curriculum. Each cycle description will be followed by a summary of the interview held between myself, as researcher, and the teacher at the end of each cycle. Finally, I will summarise the main events and achievements of the project.

4.2 Initial Meeting

December 2001.

The teacher-; Mrs. J, explained her planning and overall objectives for the following term. Her programme aims included 'reflective learning', which involved students in goal setting, planning and self-evaluations. She stated this was a philosophy that she currently implemented in every area of her teaching other than mathematics. Mrs. J felt that mathematics was her

weakest area of teaching and one she wanted help to improve. She particularly wanted to break away from a reliance on the textbook, without abandoning the textbook, and she wished to include more open-ended problem solving in her programme.

In our discussion, we explored the potential benefits of establishing a journal writing programme in mathematics: writing requires the students to think about their thinking, slows their thinking down and exposes that thinking to the teacher. We agreed that Greenwood's (1993) seven criteria for mathematical thinking (Appendix 1) would provide a useful starting point to guide students in journal writing.

At this stage in the project Mrs. J stated that she supported the concept of writing in mathematics, that it tied in with the philosophy of 'reflective learning' and that she had high expectations that journals would be valuable learning tools for her class. However, she was concerned as to how she might use journal writing for assessment.

We both anticipated that journal writing would impact on Mrs. J's mathematics programme and her approach to teaching mathematics but, at this stage, neither of us were able to predict the degree, or the nature, of that impact. We anticipated that journal writing could assist students with the development of skills required to explain their thinking and communicate ideas in mathematics. Given our awareness of the PYP mathematics scope and sequence guidelines, we also wondered if the journals would support assessment of those skills, particularly in relation to specific PYP guidelines.

We discussed our respective roles of teacher and researcher. At this point Mrs. J indicated that while she appreciated my need to observe, she felt very insecure about how to begin the programme and requested that, initially at least, I develop the prompts to stimulate student writing and assist her to introduce the concept to the class. Thus, my role of researcher was expanded

to include that of mentor, for the early stages of the project at least. We agreed that we would work together until Mrs. J felt confident enough to take ownership of the programme herself.

To establish a journal writing programme, we decided that the main objectives of the first cycle would be to:

- establish a routine for journal writing,
- fine tune the management of the programme,
- trial a variety of prompt types and stimulants to write,
- trial ways in which to encourage students to share journal entries with their peers, and
- establish a procedure for providing feedback to the children about their journal entries.

We aimed to keep thinking and communication as a strong focus of the journal writing programme, without, at this stage, being a specific objective. In line with the action research model, we agreed that we would review progress after a fixed time period and adjust the journal writing programme according to our findings.

We anticipated the second cycle would provide a clearer understanding of the uses and value of the journal entries, and their contribution to, and effect on, the existing mathematics programme. We expected the writing journals to impact on Mrs. J's assessment of her students' mathematical learning, but we were, at this point, unsure what this impact might be. We were prepared to run a third cycle, but, at this stage, we were unsure as to what would be the focus of this cycle, other than to continue fine tuning what we would develop during the first two cycles.

In preparation for the programme implementation, we reviewed resource material from the web site www.ucs.mun.ca/. This resource included a concise overview of the benefits of journal writing, ideas on how to encourage writing, and a list of suggested prompts to begin with.

4.3 Pre-programme preparation

The first cycle of the project was planned for a six-week period. For the initial trial, Mrs. J suggested that the children write in their journals twice a week. We would assess the timing and length of the sessions as the trial continued. We expected to trial a variety of prompt types and teacher response formats. Although we decided to use some pre-planned prompts to stimulate writing, we recognised the need to use what the students developed in class as this would provide valuable prompt material with the greatest potential for providing relevant insight into student learning and understanding.

Mrs. J agreed to keep a journal in which to record her own thinking about the mathematics. This would provide an opportunity for her to share ideas, strategies and thinking with her students. We decided that this journal could also be used to record observations of students and reflections on the effectiveness of lessons. In addition, it could be used to write thoughts and ideas for follow-up sessions and future lessons. While agreeing to trial a journal, Mrs. J stated a suspicion that she would most likely use the journal writing time to assist ESL students to record their ideas; she didn't think that she would always have time to keep her own journal.

We were both unsure as to how we would respond to student journal entries at this stage. The option of writing individual responses after each writing session was seen as desirable but also time consuming. Thus, trailing manageable methods of providing feedback to students was to be an important focus of the first cycle.

I supplied Mrs. J with what I intended* to be the beginning of a resource of prompt ideas related to number topics:

- place value

* In fact, this folder was never added to by the teacher. As far as I am aware, she did not use the resource as a source of ideas for prompts.

- times tables
- multiplication– PYP scope and sequence.

As a result of Mrs. J's concerns about the suitability of the prompts for ESL and 'lower ability' students, we decided to start with very simple prompts and to modify our approach as we proceeded.

We agreed that we would need to spend the first couple of weeks discussing with the children what writing in a mathematics journal entailed and what we (the teacher, researcher and students) expected from them. We decided to use Greenwood's thinking criteria as a basis for the initial discussion and to use the word 'thinking' often when working with the writing journals.

Permission had already been received from the parents of all the children involved and the children had discussed their involvement in the project with the teacher and researcher. The children were very keen to begin and very supportive of both Mrs. J and myself.

4.4 Cycle 1

This six-week cycle involved two journal writing sessions per week. Because Mrs. J clearly stated a lack of confidence in initiating the programme, I started by providing ideas for prompts. However, she quickly began suggesting prompt ideas herself, generally as a follow up from work done the previous day.

The first prompt asked the students "*What is mathematics and how does it make you feel?*" Mrs. J anticipated that most students would probably mention computational operations in their responses. She expected the 'higher ability' students to feel good about maths but her 'lower ability' students not to enjoy maths at all. She made no mention of expecting students to write about thinking, problem solving, metacognitive knowledge or strategy use.

The students supplied a wide range of responses to this prompt from "math's is a test...." and "maths is plus and minus and times" to "maths makes my brain

work hard, it makes me think". Some were prolific in their writing, others managed only a line or two. Most students claimed to like maths, and many stated that maths was important. Some said that maths was hard, some said it was easy. There was no consistent pattern or variance between 'high ability' students and 'low ability' students.

After the first session of journal writing, I read the entries and wrote individual responses in each journal. I timed how long the process took (around 20 minutes altogether). I then shared this information and the responses, both the students' and my own, with the teacher. Mrs. J, expressed surprise at the generally positive attitude of most of the students towards mathematics. She was particularly surprised that all but one of the five lower ability students stated that they enjoyed maths and found it fun and that 2 of the higher ability students stated that they found mathematics difficult and that they felt they were not particularly good at it. Mrs. J stated that 20 minutes was an acceptable amount of time to spend reading and responding to the journal entries and that she felt, therefore, it might be viable to write responses at the end of each journal writing session. We agreed that I would trial this for the first two or three weeks and then she would start.

Mrs. J, as planned, started a number related mathematics topic, focusing on multiplication, from the textbook (Heinemann Mathematics 4, 1993). Her general routine in mathematics was to begin with 20 'math mental' problems in any of the 4 operations, followed by a short time on a weekly maintenance sheet that included ten daily problems. The time allowed for this second activity was limited to the time it took the first 5 students to finish. This was marked together, with a show of hands requested at the end to indicate individual scores in each of these activities. This was followed by homework marking. Next, Mrs. J would direct the student's attention to the concept presented at the top of that day's page in the textbook. She would discuss this with the class and work a couple of examples before directing the students to either finish the page and do another for homework, or work part of the page in

class and finish the rest for homework. While the children worked from the textbook problems Mrs. J would circulate giving help as required. The routine was established to the point that the teacher rarely had to give instructions as to what to do next; the students would automatically move on to the next activity.

In the second teaching session, I had prepared a prompt related to the strategies the students used for learning their times-tables. However, this was modified to match Mrs. J's desire to obtain feedback on how the students felt about the previous night's homework activity involving the 2 and 3 times tables. While I was excited that Mrs. J felt involved enough in the project to suggest a prompt herself, we had already asked the children how they felt about mathematics during the previous journal writing session. We needed, at this early stage, a prompt that could be used to generate discussion of mathematical thinking and learning in an attempt to develop journal writing as a thinking and communication tool. As a compromise, we asked the children to write an explanation for their peers who had been absent the previous day, to explain for these missing students, exactly how they had solved one of the problems from their homework.

Mrs. J began the math session in the same way as always, with the two maintenance activities. When the children went to retrieve homework, she directed them to sit together on the mat first for a talk. At this point Mrs. J reintroduced me and we proceeded to discuss the concept of writing in mathematics with the children. We worked together on this, probing, expanding and reiterating ideas as the children shared them, until we felt they were ready to start writing. We then suggested that one of the most exciting things about mathematics is that there are always lots of different ways of solving the same problem and one of the fun things to do in maths was to pick each other's brains as to the ways each of us had solved the same problem. We suggested that some people chose to work carefully and slowly working through every step, while others spotted short cuts and tricks. The children at

this point volunteered information as to who in their class fitted these two general descriptions. We then pointed out the fact that there were 5 children who had missed maths the previous day and who may, therefore, need help understanding the homework. We directed the class to explain in their journals, for the benefit of the missing students, exactly how to solve one of the problems including what they thought at each stage of solving the problem. Inevitably, most of these journal entries were of the "first I did...and then I ....." nature, with little explanation of their decision making process included. However, even though most of these students 'got the right answer' when they marked the homework, the journal entries revealed that many students failed to recognise, or were unable to explain, the relationship between multiplication and repeated addition.

Once again, I wrote the responses to the journal entries and reported my findings back to Mrs. J. I felt that the class fell into 4 main groups. The first group explained the problem clearly and I considered, at this early stage in the programme, that they could move onto developing skills in writing explanations by being asked to explain something a little more involved. The second group, I thought, had probably understood the problem but had fallen short in their explanation of the relationship between repeated addition and multiplication. These students needed another chance to explain a similar problem to develop their skill not just in the problem at hand, but in writing their explanations of that problem. The third group revealed a lack of understanding altogether and needed time working with concrete manipulatives in order to develop enough understanding of multiplication as repeated addition to explain this relationship orally before attempting a written explanation again. The fourth group consisted of those students who had been absent and needed a chance to write an explanation for the first time.

During my report back, I became aware that this was a lot more information than Mrs. J had anticipated. She had expected the journal entries to follow the textbook explanations more closely and to confirm her students'

understanding, having recorded this expectation, this time, in her own journal writing. She seemed unsure of what to do with the students who had failed to do this. Grouping and planning in such a way as I was suggesting was not something this teacher would normally do and she seemed concerned that this was more than she could manage. We reminded ourselves, at this point, that the journal writing programme was not a mathematics programme in itself. It was to supplement the existing programme, to add a further dimension to Mrs. J's ability to teach and assess her students in mathematics. Mrs. J stated that she wanted to maintain her mathematics programme while at the same time, make the most of journal writing. She did not want journal writing to run her mathematics programme.

Mrs. J's reaction to these students' journal entries suggested to me that the value of such journal entries was affected by the teacher's ability to;

- understand the learning objectives behind a given textbook activity
- recognise what a student's journal entry revealed about that student's understanding of mathematics
- know what to do to help students who reveal a misunderstanding or need for further learning
- adapt to the individual mathematical needs of her students

I chose to exercise my role as mentor and use the follow-up lesson as an opportunity to develop the concept of explanations in mathematics for both the students and the teacher. Before beginning the lesson, we asked the students whom we had identified as being successful in writing explanations, if they would like to read their journal entries out for the benefit of the students who had been away. The students were very keen to do this and there followed an excellent discussion as to what had made these explanations clear and easy to understand. Mrs. J and the students felt very comfortable with this form of modeling. The words 'thinking', 'explain', 'clear' and 'understand' were frequently used by the students when discussing the writing.

Mrs. J and I met after this follow-up session and discussed our thoughts on the programme to date. Mrs. J stated that she felt very excited at the opportunity the journal entries gave her to assess whether or not the students could explain their thinking and understanding. She also, at this point, began to relate what the students had written to the way she had taught in class. Mrs. J raised a concern that particular students may have misunderstood because of the way she had taught and began considering a different approach for some of these students. She stated that she may not have made the connection between multiplication and repeated addition explicit enough, that she had just thought the children would 'get it' from the work in the textbook. She was also concerned that she might be missing what the 'lower ability' students might be thinking. She moved the groups so that these students sat up front and moved the 'more capable' group back. Mrs. J also stated that she could see how to use these journals to help her sometimes to follow up with groups of students who held the same or a similar misunderstanding.

We discussed the fact that for these journal entries to provide maximum information about student thinking, the students needed to develop their skills in explaining. We planned a role-play modeling session for the next day where we would demonstrate for the students some of the techniques we wanted the students to use when writing their journals. We related these techniques to Greenwood's first three criteria for mathematical thinking, which we also displayed on a chart in the classroom:

- Everything you do in mathematics should make sense to you.

- Whenever you get stuck, you should be able to use what you know to get yourself unstuck.

- You should be able to identify errors in answers, in the use of materials and in thinking.

Over the next two weeks we revisited these thinking criteria as we role modeled writing journal entries and led discussions around shared student journal entries. During this time, both Mrs. J and I provided prompts for journal writing including:

- Write a story for this equation; (6 x 3) + 5 = 23
- What did I need to know to be able to solve last night's homework problem?
- (after a times tables investigation project indicated by the researcher) What did this activity make you do? How is it different to working from the textbook?
- Write a question to go with this equation; 4,792 x 24 = 115,008 (initiated by the teacher, looking for a sense of reasonableness).

At this stage, both Mrs. J and I read the journal entries and shared the job of writing responses. We provided one-on-one assistance to those students who we felt still struggled to explain their thinking or expand on their ideas. Assistance included consultations and the use of re-prompts, that is, prompts to encourage students to respond to our responses, to expand on or re-explain something they had already written about. We also started adding into our responses directions for individuals to reconsider what they had written, challenging them to spot a mistake or to consider the sense or reasonableness of what they had written. The students began to look forward to reading our responses to their writing and willingly wrote back to us when required or re-prompted to do so.

The fourth prompt: "*Write a question to go with this equation; 4,792 X 24 = 115,008*" resulted in some spectacularly unreasonable responses:

> "Alex every week gets a box full of 4, 792 apples. If Alex gets a box full of apples for 24 weeks, how many apples will he have?"

Other entries indicated significant misinterpretation of the equation:

> "I have 4792 packets of tennis balls and 24 badminton [shuttles] in each bag, how many are there altogether?"
>
> "Lauren and Hedd made 4792 dollars and gave it away to all 24 best friends and by the end of the day they had give away 115008."

Mrs. J had a lot of fun discussing these with the students and then gave them a similar prompt to write about the next time. She was pleased to see that the second time more of the students really did think and consider the reasonableness of their responses, producing much more thoughtful and reasonable stories to go with their multi-digit multiplication equations. However, some students continued to write inaccurate or inappropriate stories. This was a prompt type that we felt needed to be presented frequently and regularly to monitor the children's true understanding of mathematical equations.

With regard to writing responses to student journal entries, Mrs. J noted that at first she had found it difficult to know what to write. I observed that she did indeed often write a comment rather than a response. For example, she wrote "Good thinking!" when it may have been more useful to the student to have written something like ... "I like how you explained two different ways of solving this problem. I wonder if one way is better than the other or if you think you might use each different method at different times?". Because of this I decided to stay involved in writing responses to student journal entries. We used a collaborative, interactive approach, involving reading the entries first and discussing suggestions as to the types of response that could be made in some journals, outlining the reasoning behind these.

During this first cycle, we had given the ESL students the option of writing in their journals in their own language. Two girls had accepted this idea and wrote in Finnish. Mrs. J and I discussed how best to deal with these entries and decided to ask the girls' parents to help by translating into English for us what the girls had written. The girls were happy with this arrangement and wrote willingly in their own language for the first two weeks. Then, of their own accord, both girls started writing in English. At first these journal entries were sketchy and difficult to follow, but towards the end of this first cycle, the girls became more confident in writing and often used pictures or diagrams to explain when their words couldn't. Both Mrs. J and I promoted this idea and

both girls were invited, on separate occasions, to share their diagrams and pictures with the class. We were able to use these examples to demonstrate to the class that explanations in mathematics need not always be in words; that pictures, diagrams, charts and graphs can be used to explain as well.

4.4.1 Summary of cycle 1

At the end of this first six-week cycle we had established a routine of keeping writing journals in the mathematics class, trialed a variety of prompts, and experimented with writing responses to the students' journal entries. We had experimented with ways of sharing student writing and modeling good thinking and thoughtful writing. Mrs. J had attempted to keep her own journal but had only managed to write in her journal twice. She had indeed, as she had indicated at the start of the cycle, used the time to circulate, work with individuals, particularly ESL students, or to prepare for the next stage of the lesson.

4.4.2 Interview with the teacher at the end of cycle 1

This was an informal interview, addressing three main questions:

1. What do you (the teacher) think of the programme so far and what impact has it had on your existing mathematics programme? (reflection)
2. Where have we got to? What have we achieved? (reflection/evaluation)
3. Where do we go to from here? What comes next? (planning)

Mrs. J felt that in the six weeks since starting the project, the writing journals had become an integral part of her mathematics programme. They had allowed her to still use the textbook as the basis for her teaching while, at the same time, shown her how to take a sideways step and begin teaching to individual needs. She felt that the journals enabled her to be more open-ended in her approach to mathematics. By having to write about concepts, ideas or thoughts related to work from the textbook, Mrs. J felt that both she and the students were led to explore a deeper meaning behind the textbook activities.

We reviewed the prompts we had used. We were able to identify many that we could classify as attitudinal prompts and others that could be labeled instructional. Using ideas from DePillo, Sovchik and Moss (1997, Appendix 2) we further classified the prompts into four categories:

- Instructional: prompts that asked a student to explain how to do something, or what something meant
- Contextual: prompts that asked a student to describe a disposition or attitude
- Reflective: prompts that asked a student to consider the effect of something on their learning or understanding
- Miscellaneous: including prompts that asked students to apply some aspect of mathematics to everyday life.

Mrs. J suggested that she might be able to use this chart to generate new prompts and as a guide to ensure that she provided a variety of prompts. She felt that contextual prompts were the easiest to devise but that instructional and reflective prompts had the greatest potential for providing the students with an opportunity to expose their understanding of mathematics.

While Mrs. J valued the journals as a record of student thinking, at this stage, she saw their greatest potential as a formative assessment tool that would influence short term planning. She saw the potential for journals to expose which students had not understood a given concept and who would need further instruction.

Mrs. J stated that journals could assist students' self-assessment of their own mathematical learning and understanding. In relation to assessment, we discussed again Greenwood's criteria for mathematical thinking. We agreed that these were not learning objectives that could be assessed in a single unit. These were criteria that needed to be considered across the whole year, to be used as a learning tool and as an assessment tool. To maximise the effectiveness of these criteria, the students needed to be involved in using

them regularly as they considered their own mathematical learning, through self-assessment.

As part of the reflective evaluation, typical in action research, we re-read many of the students' journals and we were able to identify several examples of journal entries that related to Greenwood's thinking criteria (although at this point we could not be sure that the students' consciously considered these). For example, using the prompt "*How do you find the missing number in this equation; 24 -:- __ = 3 ?*", many students explained how they used what they knew about their three times tables and the relationship between times and divide to solve this problem. These journal entries began to give us an insight into how these students 'use what they know to get unstuck' as suggested by Greenwood's second criteria for mathematical thinking. Other students, equally familiar with their three times tables did not make the connection between times and divide, and therefore did not make use of what they already knew about the three times tables to help themselves get unstuck. They worked it as a straight division problem. Other students again, misunderstood the entire exercise and provided inaccurate solutions. Mrs. J and I agreed, that to make the connection between journal responses and the thinking criteria, discussion was required during sharing sessions. For example, sharing journal entries of students who had recognised and explained the connection between times and division with their peers might be a more effective way of modeling such a concept than a teacher led example. A teacher led discussion of student thinking has the potential of making that thinking explicit for other students who may not have been thinking in the same way.

On other occasions, after re-prompting, students were able to recognise and act upon errors in their thinking or working. We had modeled this criteria twice during the six weeks, demonstrating how one can write not only what one knows, but also what one still needs to find out, or what one thinks they might have done wrong. Several of the children had, towards the end of the cycle,

pointed out errors independently, or identified the point at which they had got stuck. We felt then, that the journals had the potential of contributing to an assessment of the student's achievement of at least some of Greenwood's criteria for mathematical thinking.

Mrs. J felt that the journals were useful as both a learning tool for the students, in that they made the students think and be aware of their thinking, and as an assessment tool, in that they provided a record of student thinking and understanding. She stated, however, that the journal alone was only of value as a short-term assessment tool and she wondered if they could provide sufficient information to contribute 'formally' to long-term assessment (by this she meant against a summative record or assessment chart related to specific learning criteria).

We decided to formulate a rubric around Greenwood's criteria for mathematical thinking and to trial this as an assessment tool in mathematics, supported by the journals, to see if it would provide a record of growth in student thinking and understanding. We developed the initial Thinking Rubric together (Appendix 3) as a generic rubric to assess learning criteria identified in the PYP scope and sequence based on five main areas:

- Communicating ideas
- Strategy use
- Computation
- Attitude/aptitude
- Topic work learning outcomes

The aim of the rubric was to be as generic as possible to allow the teacher to re-use it at the end of each topic or at the end of each term. These criteria included a mixture of content based learning criteria and thinking/process based criteria. We wanted to be able to plot each student's level of achievement against the first four headings and to see if, over time, we could observe changes in individual student's profiles of mathematical achievement. This idea was modeled on an assessment technique Mrs. J used to plot her

students growth related to their use of information technology and resource based learning strategies (Appendix 4) and her use of rubric based reporting forms related to specific studies of interest (e.g. Appendix 5). The challenge then, was to apply the generic rubric we had just developed, to the writing journals.

I was conscious of the fact that my roll as mentor had the potential to overshadow my roll as researcher. I therefore took the opportunity to distance myself from the classroom for most of cycle 2. I suggested that Mrs. J run the journal writing programme independently for the following 4 weeks, using me for support as required.

4.5 Cycle 2

This cycle lasted 4 weeks and had two main aims:

1. To enable the teacher to run the journal writing programme independently and give me an opportunity to observe from a distance, her use and choice of prompts, her use of student journal entries, her writing of responses to individual entries and the consequent influences on her teaching programme.
2. To trial the development and use of thinking based rubrics and their application to the assessment of student learning and understanding through journals.

At the start of this cycle Mrs. J introduced a new mathematics topic to the class; geometry. She used the writing journals to get the students to indicate the extent of their knowledge of the topic before starting the unit. She provided them with the prompt "*What is geometry?*" At the end of this unit of study, she asked the same prompt and was able to look back and compare the level of knowledge and use of language to help indicate each student's growth in knowledge and understanding of the topic. Mrs. J also, of her own accord, and for the first time in mathematics, listed the learning objectives she expected to cover in geometry with the students. She fitted those learning objectives into

the fifth column of the newly developed Thinking Rubric (Appendix 6). This was not what I had expected as I struggled with the concept of fitting the learning objectives for an entire topic in a single column. At this point I privately questioned the validity of the fifth topic-based column, fearing that it encouraged a single grade assessment approach to topic assessment and was therefore interested to observe how Mrs. J would use this in her final assessment of the topic.

In a related science unit, Mrs. J used a pre and post learning approach to journal prompts when she asked the students to write about what they knew about the concept of average. Again, a significant growth in the students' knowledge and use of mathematical language was observed.

On another occasion Mrs. J tested the students' understanding of the concept of an angle, asking: "*Tell me everything you know about angles*". She used these journal entries to stimulate discussion at the start of the next day's lesson on angles, before starting the textbook exercises.

During the third week of the geometry unit Mrs. J asked the students to write an explanation of a homework question they had done the previous night. As this was a geometry activity directing students to cut out various shapes and use them to create another shape, the students basically wrote a series of directions similar to those in the textbook. These journal entries failed to give Mrs. J any insight into the thought processes the students had used to create the new shape.

In contrast, during an unrelated social studies activity that required the students to invent a board game, Mrs. J took the opportunity to 'mathematise' the situation and created a problem solving challenge. She asked the children how they could draw a games board with 81 spaces, on a given piece of cardboard. The students worked in groups of 5 and Mrs. J observed as they argued, discussed, debated and trialed various ideas before solving the

problem and drawing the boards. Mrs. J told me later that she had never done anything like this for mathematics before and was extremely excited at how easily she had noticed the opportunity this time to initiate an impromptu mathematics challenge, outside mathematics time. As a follow up the next day, she got the students to describe, in their writing journals, how they had divided their board up into 81 spaces. However, again the student's responses failed to reveal their thought processes behind their problem solving. Mrs. J was able to use these entries to confirm that all of the students had understood the concept of using 81 = 9 X 9 and then to divide each side into nine equal lengths by using a calculator. While we were impressed with the problem solving activity and the student's ability to explain their solution, we did wonder if it would have been possible to prompt the students to write about more than just their solution. We decided that an alternative prompt might have been "*Tell me what happened yesterday during unit studies when we had to make a board game?"* or, *"How did you behave like a mathematician yesterday when you had to make a board game with your group?"*. We predicted that a more open-ended prompt had greater potential for soliciting a more detailed response from the children. Unfortunately we ran out of time to test this theory fully.

Towards the end of the 4-week unit, Mrs. J presented the students with the prompt "*Describe, in detail, a secret three dimensional shape*". This prompt stimulated the students to use vocabulary they had developed during the geometry unit and was successful in indicating students' misconceptions of many of the geometrical terms they used such as edge, corner, point, curve and side. This feedback prompted Mrs. J to revisit these concepts and further explore the attributes of various three dimensional shapes. Following this, she re-presented the prompt and observed, through the students' journal entries, that this time students were a lot clearer and more accurate in their descriptions of their secret three-dimensional shapes.

During the first week of this unit I had rewritten the Thinking Rubric as a Writing Journals Rubric (Appendix 7) to be used to assess a single journal entry. I had trialed this rubric by going back over the first cycle journal entries and found it was quick and easy to use. I considered each prompt and classified it into one of the five groups. The rubric criteria were considered and selected according to which level a journal entry fell into. For example, *24 -:- __ = 3*, fell under the heading 'computations'. The student who wrote "I thought 3 X 8 equals 24 so if I divide 24 by 8 it equals 3" would score 1 on writing journal rubric, as he had instant recall of a basic fact, and manipulated the numbers to minimise computation. A student who wrote "I draw 24 dots and if I divide them up into three groups and share them out and then I counted 8 in each circle" would score 3 on the same rubric as they did not use recall basic of facts to solve the problem. The student who wrote " I would use a calculator and do 24 X 3 and then it would be 72" would score a 4 as they have given an answer that is confused.

Mrs. J initially doubted her ability to identify which heading a journal entry belonged to or her ability to maintain such a record. However, she agreed to trial the rubric and the accompanying record sheet (Appendix 8) during the geometry unit and discuss her findings with me at the end.

4.5.1 Interview with the teacher at the end of cycle 2

This informal interview discussed:

1. How the teacher had felt about the independent implementation of the journal writing programme? (reflection)
2. How the journal writing programme had influenced the teacher's mathematics teaching? (evaluation)
3. How the journal writing programme had contributed to the teacher's assessment practices? (evaluation)
4. Suggestions for the improvement of the journal writing programme (planning)
5. How, and if, the teacher had used the rubrics (reflection/evaluation).

Mrs. J stated that she had used the 'Prompts for writing journals in mathematics' chart (Appendix 2) on two occasions to help her decide on a prompt type. She reported that she now felt comfortable using the journals and that the students enjoyed them. She noted improvements in the quality of entries; students wrote in greater detail and with a lot more thought. This assertion was clarified with examples of journal entries that exposed a student's thinking about their own understanding. For example, this student wrote about a times tables investigation:

> "I have learned more about my times tables than I knew before. I never knew there were so many neat patterns, it was fun. The patterns are easy to remember".

While another student wrote about Geometry (after being given the second prompt "*Why do you think we learn about Geometry?*"):

> "I think we learn about geometry because we might need the shapes we use in geometry and the other things about it in our daily lives because it would be hard if your child would say "dad/mum, can you buy me a firework that looks like a sphere" and you do not know what it looks like. That would not be much help at all! And if your child said "dad/mum what does a railway line look like?" and you do not know how to explain it because you do not know what parallel lines is."

At the end of this unit Mrs. J used the Thinking Rubric (Appendix 3) and a standardised marking sheet (adapted from one she used for science and social studies unit) to record her assessment of her students in mathematics, and geometry in particular (Appendix 9). In recording her assessment of the students for this geometry topic, Mrs. J commented on all four thinking based headings, as listed in the rubric; communicating ideas, strategy use, computation and attitude. I was interested to note that the topic of geometry was covered by two separate headings:

- Classifying shapes

- Use of angles.

This was despite the fact that she had placed all of the topic based learning criteria for geometry inside one column in her learning criteria rubric (Appendix 6).

The marking sheet was then stored in the students' portfolios. The students were already familiar with this reporting format, as it had been used previously for science, language arts and social studies. Mrs. J reported that the use of this assessment process had resulted in an increased confidence of her assessment of mathematics. She said she had referred several times to student's individual journal entries while making assessment judgments and used them to confirm her professional judgment. She found the writing journals particularly useful for differentiating the mathematical learning/understanding of her 'middle' students.

Previous to this research project, Mrs. J collected a sample of student work at the end of each unit for inclusion in the portfolio. These included a list of 20 answers to oral basic facts questions (the questions were not included), a sample of a weekly maintenance sheet and the student's answers for that week, and a work sheet of multiplication questions. At the end of the geometry unit, Mrs. J placed her marking sheets into each portfolio as described above. She also gave the students a task of drawing some two dimensional shapes on graph paper. The students were directed that they were to draw only and were specifically instructed not to include any writing in this task. These pictures were coloured and then placed into the folder. No explanation of the task or assessment criteria, were provided. At this point in time, no journal entries were selected for inclusion into the portfolios.

Overall, Mrs. J felt that she was a lot more confident teaching mathematics now and less dependant on the textbook. She was particularly excited about the games board exercise that was not only outside the textbook, but also outside the designated mathematics time. She felt that having to provide

prompts for journal writing was encouraging her to look past a textbook exercise and more towards the mathematical thinking she wanted to achieve with her students.

In this cycle Mrs. J trialed the use of the Writing Journal Rubric, recording individual assessments of individual journal entries on the record chart. Like me, though, she had done this at the end of the unit, rather than in response to reading and providing feedback to the journal entries. Unlike me though, she had not labeled each entry against a rubric column. She had, in fact, given each entry an independent title, e.g. problem solving (for the prompt that asked the children to explain how they had made their games board), applying mathematics (for the prompt that asked how the students had solved a geometry puzzle in the textbook), reflective (for the prompt asking how students felt about the test). Because of this, she did not in fact use the rubric to assess the journal entries at all. Once again, she used her 'professional judgment' and the generic rubric:

- 1: Excellent, exceeds criteria
- 2: Very good, above criteria
- 3: Adequate, within expected criteria
- 4: Experiencing difficulty, below criteria.

Neither of us was sure that this recording of individual journal entry assessments added value to the overall assessment of each students mathematical learning. It appeared that the writing journal rubric was surplus to her requirements. We suggested that the chart needed to be kept for a longer period of time than we had trialed it for. We were both able to see potential for it showing up patterns that may indicate learning needs or strengths in individual students.

4.6 Cycle 3

As the class in which this research took place was in a northern hemisphere international school, this final cycle fell into the final few weeks of the academic year with all the added pressures and time constraints that the end of a school

year entails. Mrs. J was involved in collecting final data, including portfolio entries for all areas of the curriculum, as she finished writing the end of year reports. On top of this, the entire school had to be packed as it was moving to a new facility at the end of the term. It became clear at the start of this cycle that the class routine was to be heavily disrupted during this time and that this would undoubtedly affect the journal writing programme. Because of this, Mrs. J and I decided to keep our objectives for this cycle as simple as possible. We aimed to:

1. Continue the journal writing programme in its present form as much as possible
2. Develop and trial a Self-Assessment Rubric from our original Thinking Rubric, for future consideration.

In addition, I also hoped to ascertain if Mrs. J would use any of the journal writing entries, or any of the students' writing in mathematics, as contributions to the portfolio before they were sent home at the end of the year.

During these final few weeks, the school also participated in The University of New South Wales primary schools mathematics competition. This was an annual multiple-choice type of test administered under examination conditions with a time limit. Mrs. J offered her students the choice of participating in the competition. The entire class chose to participate and proceeded to spend several days practicing by working through copies of competition papers from previous years. Mrs. J presented the students with a pre-prompt "*How do you feel about doing the NSW mathematics competition?*" and a post-prompt after they had completed the test, "*How do you feel now about the NSW math's competition?*" Responses varied, but in many cases, students volunteered information not only about how they felt, but also about how they had prepared or studied for the test. This could have provided an opportunity to share and discuss the student's strategies for improving learning. However, presumably because Mrs. J was distracted by everything else that was going on at this time, she did not take this opportunity. Her written responses to students only

commented on what the children had written about how they felt, encouraging them to 'feel positive' and 'try harder'.

The Self-Assessment Rubric (Appendix 10), a simplified version of the original Thinking Rubric, was trialed with some of the students. The students were able to select their assessment level easily and when informally interviewed by either Mrs. J or myself, were able to explain why they had selected a particular level for themselves and what they might do to improve. This exercise would have provided excellent opportunities for writing prompts, had there been more time.

Within this cycle Mrs. J begun a fractions topic and included the prompt; "*What do you know about a half?*". This prompt solicited from the children an exceptional amount of information. Some students included relationships between half as a fraction, a decimal and a percentage. Unfortunately, while Mrs. J did take the time to read the journal entries, she did not, on this occasion, have time to write individual responses or to encourage the students to share their journal entries with their peers.

4.6.1 Summary of cycle 3

Despite the anticipated disruptions during this cycle, the objectives were achieved to some degree. While Mrs. J did not always take full advantage of the journals to communicate with her students, the children did still use them to communicate with her, writing very honestly and thoughtfully. Both Mrs. J and I were pleased with the detail and confidence with which the students wrote in response to the final prompt about one half. These entries were distinctly more detailed, thoughtful and revealing than entries at the start of the project and suggested to us that the students were becoming more comfortable with using the journals.

Unfortunately, Mrs. J did not select, or encourage the children to select, any journal entries for inclusion into the portfolios. The Self-Assessment Rubric

was only trialed informally with a few children, and again, was not included in the portfolios.

4.6.2 Final interview with the teacher

Before this interview took place, I sent Mrs. J a copy of 10 questions for discussion (Appendix 11). This interview was, therefore, more formal than the others, in that it followed a pre-established agenda. Even so, Mrs. J and I maintained the relaxed air of the previous interviews as we reviewed our collaborative efforts.

The aim of this interview was to summarise our progress with the writing journals. We needed to evaluate the role of journal writing in Mrs. J's mathematics programme, and to decide if they would continue to be part of her mathematics programme the following year. We wanted to discuss the impact of these journals on both Mrs. J's teaching and on her assessment of her students in mathematics. We needed to find out what changes would need to be made to the programme before possibly implementing it in other classes next academic year. And finally, I needed to find out what roll the rubrics played in both Mrs. J's mathematics programme and her journal writing programme. I wanted to know if the rubrics assisted her to implement the journal writing programme or if they stood apart as a separate, unrelated assessment tool.

The following is a summary of Mrs. J's responses to the 10 questions.

1. Is there a particular category (or categories) of student who you feel particularly benefit from the exercise of writing mathematical journals?

The higher ability children probably get more out of journal writing because it is easier for them to put their thoughts into words. The lower ability students just try to please the teacher, they don't really develop their thoughts. Mrs. J explained that by this she meant that the lower ability students just write what they think you want them to write. I asked if she could show me an example

of this. While looking through several journals we were surprised by the amount of detail many of these 'lower ability' students had actually included in their journal entries, e.g. the special needs student, when asked how to find the missing number in *24 -:- __ = 3*, wrote "you count up how many 3's in 24 so in the what you put the 8 in the whats place". However, Mrs. J explained that this journal entry showed that it was difficult for this student to express himself in maths, particularly when he had to write, so she felt that he, and some others, just wrote the 'first thing that came into their heads'. They could not explain their ideas properly so ended up 'writing what they could in a way they thought the teacher would accept'. For example, this same student, when asked "*What is geometry?*" wrote, "Geometry is lots of shapes like a rectangle and geometry is important." (This prompt was given at the start of the unit, and may indeed be representative of all he knew about geometry.) For this reason, Mrs. J didn't think the lower ability students benefited as much from journal writing as other students. (The same student, when writing what he thought a half was, wrote "I know that you can turn into a half of any kind of food. Like if you had 7 friends and a big pizza you can split it in half for your 7 friends and you." While Mrs. J acknowledged that this entry helps to reveal the child's level of misunderstanding, she did not see this journal writing process as directly benefiting the student.)

Mrs. J also felt that there was differential benefits for ESL students: *It's very hard for the ESL students to write so I'm not sure if they benefit as much.* This response surprised me as we had previously expressed pleasure at the way one ESL student had exposed an understanding of mathematics beyond Mrs. J's expectations. She had also previously stated that she had observed ESL students talking more willingly about their mathematics when it was related to a journal entry than if they were required to discuss something related to a textbook exercise or a class task. It may be that Mrs. J interpreted these observations as a benefit for the teacher rather than a benefit for the student.

2. Is there a particular category (or categories) of student who you feel you learn more about by reading their journal entries?

Yes, the middle groups of students. Before the journal writing I could never really be sure if they got it. The middle group students don't really contribute as much as higher ability students and they don't get as much help as lower ability students, so this is a good way for me to find out what they know, or what they can tell me about.

3. How often do you directly follow up with an individual student as a result of something you read in their mathematics journal?

Two or three times per session-: Mrs. J stated that she either wrote a re-prompt for or spoke directly with an average of 2-3 students each session.

4. How often (as a %) do you plan a follow up session for a group or the full class in the form of a full lesson, a discussion, or questioning for clarification or further explanation?

10-20%. I generally only planned a follow-up session if the whole class or a large group had a similar problem. Normally this was when I hadn't explained something properly or if the kids had not understood the prompt, or if I felt they fell short of explaining fully. In geometry this happened more than in number so it may be topic dependant.

5. How much (as a %) do the children's journal entries contribute to your assessment of the students' learning in mathematics?

It depends how you look at it. Reading the students' journal entries is 100% assessment every time you read them. But overall, they would provide around 40% of the information I used to write the end of term reports. They are like keeping a running record of what the students are thinking and doing in mathematics. I used both the journals and the rubrics a lot when I wrote the kid's reports. When it came to actually writing an assessment or filling out a school report, I used the rubrics the most. They were easy to use and I feel very excited about using them again next year. I used the journals to confirm

these assessments; I use them as a record of evidence for my assessment judgments.

6. How much *extra* information about a student's learning or understanding of mathematics do you think you gleam from their journal entries?

I learn a lot more from the middle students that I might not otherwise know. When I read the higher ability students' journals I mostly use them to confirm what I already know. I have found out a lot from some of the ESL kids, especially T__, she is a lot more capable than I thought before. She loves writing in her journal and will talk to me more now about math's, so I know a lot more about what she can do, how she solves problems and how much she understands.

I find out about the children's attitudes, about how they feel about themselves in mathematics. And I like that I can write back to someone if they write that they feel worried or upset about something in math's, because I think they're more likely to write about that sort of thing than to talk about it.

I sometimes find out that a kid has a really confused idea about something. The journal entry doesn't always tell me exactly what the kid thinks, but sometimes it can show me that I need to find out more about what someone is thinking, either by writing a re-prompt or by talking to them. And sometimes I have been excited to read a student's journal entry that has shown me they knew a lot more about something than I thought, like when I read a lot of the responses to the prompt about ½. The kids really opened up for that prompt, I think they were just getting used to writing in their journals by that stage and felt a lot more comfortable about writing down all of their ideas in as much detail as possible. Many of them even used pictures and diagrams. And I was really impressed with how two of the children even used what we had learnt in geometry and applied that to what they knew about ½, for example, when E_ wrote that a radius is a half of a diameter.

7. How much (as a %) do the children's journal entries contribute to your planning of the next lesson?

I don't know how much, but they only contribute to my planning if I think the kids haven't got something. Then I have to think of a better way of teaching it, we have to go back and revise something or I might have to re-teach the whole thing.

8. List, and explain, the ways in which you think your mathematics programme may have been affected by journal writing.

Journal writing is a formative assessment tool, it is ongoing. The journals provide assessment information that contribute to the end of topic assessment. The information learned about student thinking in mathematics by reading the writing journals, means that any assessment I make in mathematics is more informed and supported by evidence, in the journals. The journals can be used as evidence to support summative assessment. This is where it is good if they (the journals) are tied in with the assessment rubrics, because we are then all focusing in on the same thing. If the students think I'm looking to see if they can recognise their own mistakes or try different ways of doing something, then they are more likely to do those things and show me that they can do those things in their journals. I encourage the kids to use self-assessment in everything else that they do. Now I can get them to use self-assessment in mathematics as well, by using the self-assessment rubric, but also by writing in their journals.

The journals make the kids think about what they know or what they are doing in maths. They give me more insight into student thinking because the kids have to explain their thinking to me in writing. I can read for myself, what and how they have been thinking, and I can even ask them for more information either by writing them a re-prompt or by interviewing them about what they have written.

As well as issues directly related to assessment practices Mrs. J noted changes to her instruction and learning objectives for activities.

In the same way, the journals and the thinking rubrics help me to think about my teaching. I have to think a little bit more about what I want the kids to do and then if they don't do it, or they seem to not get it, I have to think of a better way of teaching them. It's made me explain things more and slow down. It's made me realise there are some children who need more concrete maths than abstract. And I think more about what I want the children to get out of a maths exercise.

9. List and explain any concerns you have about journal writing in mathematics.

It is time consuming. It takes up time in the maths lesson, at least 10 minutes and often more if we do some sharing. And it takes time to write responses. Sometimes I think I don't spend enough time writing back, because I'm just too busy. Two or three times a week is enough.

I tried doing journal writing at the start of maths, but that didn't work because we had to wait too long for everyone to finish. I like to do it at the end.

10. List the reasons why you might encourage others to implement a journal writing programme in mathematics.

It's a good way to get the students to self-assess, to think about their own learning. It leads into using the rubrics. You could use the rubrics without the journals, but the journals make the rubrics more effective. The rubrics are more for the end of unit assessment, and the journals are used for formative assessment. The journals provide a record of student thinking and communication and provide evidence for the rubric assessment. At the same time, the rubrics provide direction and focus for journal writing. They (the rubrics) *often helped me to formulate a prompt or to focus my thinking about what I wanted the kids to write about and why I needed them to write.*

I'm still not sure about using the checklist to record the journal entry assessments. What we did was an exercise only, we would need more time to build a picture of progress. I'm not sure that the checklist is necessary. If I use the thinking rubric, and the children use the self-assessment rubric, I think it is enough. The journals provide enough information just when I read them, they add to my professional judgment and I can always look back on them if I need to anyway, which I sometimes did.

I think the kids made good progress in communication. The journal communication was important, the kids told me things and I could tell them things. It was great when I would re-prompt them and they would write back. The kids loved that. I think they were much more confident at the end, in recording their ideas. The children especially loved sharing their journal entries with the class and they loved the discussions we had around these. I think the children liked that they could write whatever they wanted to. The kids were writing more clearly at the end. They wrote about maths in the same way they wrote about everything else but their explanations were becoming more full and more logical.

4.7 Summary

We had planned three cycles for this action research. The third cycle was constrained because it fell too close to the end of the academic year. However, overall Mrs. J managed to successfully implement a journal writing programme in her grade three class.

We used assessment formats suggested by Mrs. J as methods she was familiar with and comfortable using, to develop assessment rubrics. We used Greenwood's criteria for mathematical thinking to focus attention on the students' thinking and communication skills, in line with PYP assessment guidelines. From this we were able to begin a thinking based self-assessment programme for students in mathematics, through the use of both writing journals and a self-assessment rubric.

Mrs. J used writing journals in mathematics as a record of evidence to support her professional judgment. Both the journals and the rubrics contributed significantly to her assessment of mathematics. As a tool for formative assessment, the journals enabled Mrs. J to understand better the individual needs and achievements of her students. She found that by reading the children's journal entries she felt more informed about her students' learning in mathematics. Mrs. J has recognised an increase in confidence in both her teaching and assessment of mathematics through the use of both the journals and the rubrics.

Mrs. J was able to maintain the textbook centered mathematics programme she was comfortable with, but found that the journal writing programme and the thinking based rubrics helped her to think more carefully about what some of the textbook activities were asking her students to do. She was also beginning to recognise opportunities to problematise situations and make them mathematical learning activities, outside the planned textbook based mathematics sessions. As such, the journals and thinking rubrics began to affect this teachers approach to mathematics. She had begun to demonstrate a consideration for mathematical thinking and attitude as well as mathematical content when planning a mathematics unit.

Mrs. J has become independent in her use of the writing journals in mathematics. She uses current work in mathematics to stimulate the formation of prompts, regularly providing prompts that encourage students to write about what they know, think or feel about a given topic. Mrs. J read and responded to student journal entries, and was beginning to use these responses as a form of communication and as a teaching tool. She was beginning to encourage students to meet Greenwood's thinking criteria (the first 3 at least) by encouraging them to respond to re-prompts individually as required.

Whilst finding the journals time consuming to use and respond to, Mrs. J planned to include journal writing as part of her mathematics programme next year. In addition, she would, as syndicate leader, be encouraging and assisting her colleagues to do the same. She also stated that she would be using the thinking based rubrics as an ongoing assessment tool throughout the next year, at the end of each math topic, to support the implementation of self assessment for her students in mathematics. Mrs. J found that the journals and the rubrics supported each other in that the journals provided an ongoing formative assessment record, while the rubrics helped direct and focus journal prompts.

Chapter 5

Discussion

5.1 Introduction

This project aimed to explore how a teacher who runs a primarily textbook-based mathematics programme was able to use writing journals as a teaching and assessment tool in mathematics. An indication of the impact of a new programme or practice is the measure of change it influences. The purpose of this chapter is to discuss the change that has occurred in Mrs. J's teaching and assessment of mathematics since the implementation of the journal writing programme in mathematics, particularly in relation to the research questions posed in chapter one.

Mrs. J approached this research project with a desire to affect change in her teaching and assessment of mathematics. This was influenced by her existing use of performance based assessment techniques across other areas of the curriculum. Research findings on teacher change (Borko, Davinroy, Bliem & Cumbo, 2000, Clarke, 1997) indicate that Mrs. J was at a stage in her teaching career that supported change:

- She is an experienced teacher responsible for initiating change throughout the school in other areas of the curriculum
- She has maintained a consistent record of in-service training throughout her career and is constantly striving to remain abreast of contemporary educational reform
- She independently recognised a need for change in her teaching and assessment practices in mathematics

However, despite the existence of these factors, it is unreasonable to expect that a three month project will be enough to completely change Mrs. J's

approach to teaching mathematics. It is enough to demonstrate that a change in approach has begun and that the journal writing programme has become an integral part of her mathematics programme. At the same time, there is value in discussing ways in which Mrs. J's teaching and assessment of mathematics did *not* change, despite the implementation of journal writing and use of the supporting thinking based rubrics, and in exploring possible reasons for this.

5.2 Research questions answered

1. How has the implementation of a journal writing programme affected Mrs. J's teaching approach?

Despite an initial indication of a lack of confidence, Mrs. J took ownership of this journal writing programme. She readily contributed ideas for prompts, wrote responses and encouraged her students to share and discuss their writing. She integrated journal writing into her regular mathematics programme, used the students' responses to initiate discussion about mathematics learning, thinking and understanding, and allowed journal writing to become an integral part of her mathematics teaching.

Mrs. J adopted Greenwood's (1993) criteria for mathematical thinking, displaying these in her classroom and frequently referring to them while discussing student journal entries during sharing sessions. These thinking criteria, while used by the teacher to direct students, were not used by Mrs. J necessarily in her own mathematics. Mrs. J did not consistently model mathematical thinking for her students, suggesting a lack of confidence in her mathematical thinking, or in her ability to apply mathematical thinking effectively.

Mrs. J recognised journal writing as a formative assessment tool. In support of research studies (Bagley & Gallenberger, 1992, Harris, 1994, Mayer & Hillman, 1996) suggesting that ongoing, formative assessment can affect teaching

practices, Mrs. J began to question her role in teaching mathematics. As a result of reading journal entries, she recognised that her explanations for student misinterpretation of mathematical problems was inadequate.

On several occasions Mrs. J demonstrated a change in her approach to teaching mathematics as a direct result of using the journals, including:

- Moving groups so that students requiring more support were closer to the front of the class
- Recognising that some students may need more concrete experiences in mathematics
- Using pre/post prompts as a tool to evaluate growth in content knowledge
- Prompting her students to write about angles and using these responses to introduce the topic
- Recognising, for the first time, an opportunity outside the normal mathematics lesson, to turn an activity (drawing a game board grid) into a mathematical problem solving exercise, and then prompting her students to write about the experience in their journals
- Planning follow-up sessions, either with individuals, groups or the full class, as a result of reading journal entries and recognising common needs
- Encouraging sharing sessions to become a regular part of her math class, in which students role modeled and discussed their mathematical thinking and ideas as recorded in their journals.

The use of journals in mathematics had an affect on the way Mrs. J thought about and used the textbook. The text still remained a central aspect of her programme, but in having to present prompts for students to write to, Mrs. J found that she began to look more carefully at what a textbook exercise might be aiming to achieve. As a consequence of this thinking, Mrs. J:

- Regularly used the journals to explore her students approach to, and understanding of, a textbook homework task

- Initiated a prompt, similar to a textbook exercise, to explore her students' ability to *explain* a multi digit multiplication equation *reasonably*, and followed up with a sharing session and re-prompt when she found out that many of the children needed further tuition in this
- Began to recognise and use mathematical learning opportunities outside the textbook
- Used students' journal entries, instead of a textbook exercise, to introduce a topic or idea.

Mrs. J began using journals as a teaching tool to affect student learning and understanding of mathematics. For example, she used the writing journals to prompt students to write descriptions of three-dimensional shapes. These entries revealed some students' inability to use two-dimensional terms to describe three-dimensional objects; they used 'cube' or 'sphere' to describe the shape of a face, rather than 'square' or 'circle'. Mrs. J wrote responses that directed the student's attention to the use of terms like edge, point and face, corrected their misuse of three-dimensional terms or re-prompted them to take a second look at their shape and provide more information. During the next journal writing session she prompted the class to write another description of a second shape. These subsequent entries were more accurate, and Mrs. J took the opportunity to praise students for 'better' work or 'good' descriptions.

Writing journals in mathematics can be an effective communication tool, increasing the two-way flow of information between the teacher and students (Greenes, Schulman & Spungin, 1992, Mayer & Hillman, 1996). In this project the teacher noted an increase in the amount of information students shared with their teacher through their journal entries. In line with the findings of Gordon and McInnis (1993), Mrs. J noted that her students appeared motivated to write by the fact that she would be reading their entries. They were excited to read her responses and readily wrote replies when re-prompted to do so.

Effective communication is a two-way process. While Mrs. J was beginning to use journal writing to communicate with her students, her responses to journal entries were inconsistent; sometimes merely a comment rather than a communication (e.g., Good, or Yes, or Good thinking). This may have been due to time constraints (particularly during the third cycle), but may also have been due to the teacher's inability to recognise and act on opportunities to extend learning beyond the initial learning outcomes. For example, in the geometry writing session, Mrs. J was presented with an opportunity to prompt student curiosity and promote exploration of three dimensional shapes. Instead of merely accepting a clear description of a three dimensional object, she could have re-prompted students to:

- Describe the shape of the face that would be formed by cutting their object in half horizontally, diagonally, or vertically
- Estimate the dimensions their object would need to be to fit the student inside.

Borasi and Rose (1989) suggest that journal writing provides teachers with an opportunity to expand mathematical thinking; to stimulate further inquiry and exploration. A student who demonstrates a sound understanding of a given mathematical concept can, through journal writing, be prompted to apply that learning to wider examples or alternate situations. However, the use of journal writing to extend the learning outcomes of a given activity, depends on the extent of the teacher's understanding of the topic or concept being written about. The teacher needs to have a broad understanding of the mathematical concept in order to appreciate the significance of a student's writing and it's application to a wider range of contexts. Within this study Mrs. J missed several opportunities to stimulate further inquiry and exploration through her students' journal writing by merely accepting their entry with a comment, rather than focusing or extending further attention on using the knowledge, understanding and thinking to explore or expand their understanding and use of mathematics.

Justification and proof are central aspects of mathematical thinking (Porteous, 1990). Journal writing can be used to develop skills needed for mathematical proof by prompting students to expand their thinking and explanations to include not only *what* they know, but also *how* they know it and what they can *do* with what they know. However, Mrs. J did not use her responses to student journal entries to prompt the development of these skills. Alternatively, Mitchell and Rawson (2000) developed writing frames to scaffold student writing of explanations and justifications. These frames were not trialed in this project. However, there is a possibility that they could have assisted both Mrs. J and her students. While the thinking based rubrics went some way to guide Mrs. J's teaching and assessment practices, these frames would have provided clearer guidance for both the students and the teacher in *how* to explain and justify mathematical thinking, and may possibly have encouraged students to explore their mathematical thinking beyond set criteria.

While journal sharing sessions were used effectively to model student thinking, processes and behaviors, Mrs. J did not model her own mathematical thinking, writing and explaining (outside the initial introductory modeling sessions run collaboratively with the researcher at the start of the project). This may demonstrate a residual lack of confidence in her mathematical knowledge and possibly a shortfall in her understanding of what entails mathematical learning. While Mrs. J was beginning to recognise mathematical learning opportunities outside the textbook, it may be that her content knowledge of mathematics is defined and limited by her dependency on the textbook. Thinking criteria went some way to expand her focus into procedural, contextual and metacognitive knowledge, but did not necessarily expand her content knowledge. The impact of a journal writing programme on Mrs. J's approach to teaching mathematics may be limited by her own knowledge of mathematics (Ball & Bass, 2000).

Ball and Bass (2000) explain the need to balance content knowledge with pedagogy to maximize the impromptu opportunities to teach mathematics situated in context. Journal writing allows for the use of mathematics in

context and can provide impromptu opportunities to teach mathematics. These opportunities are maximized by the teacher's ability to recognise their potential. Content knowledge, according to Ma (1999), does not just include *what* students need to know or be able to *do* in mathematics, but also how to *use* and *develop* what they know to further mathematical learning. A teacher who has a deep content knowledge can model the growth and development of mathematical ideas for their students. They can recognise where a student is up to in their understanding, where they may have gone wrong and how to work back to what they know to help them get unstuck* Likewise, a broad content knowledge enables a teacher to relate mathematical ideas to wider situations, to adapt and expand ideas and use sound mathematical thinking to solve life-like problems and to assist their students in doing the same**.

Student journal entries and the need to provide prompts, have had some affect on Mrs. J's use of her content knowledge in mathematics. In addition, using the PYP guidelines to write learning criteria for geometry may have contributed to and guided growth in Mrs. J's content knowledge to some extent by guiding her in what to expect from the students and to determine whether they have achieved a specific mathematical learning outcome. Whether or not this is enough to effect a growth in Mrs. J's mathematical knowledge was not a question this research project is able to answer definitively.

2. How did the implementation of a journal writing programme influence Mrs. J's assessment procedures?

In line with findings of several researchers (Mayer & Hillman, 1996, Miller, 1993) Mrs. J found writing journals in mathematics to be a useful ongoing, formative assessment tool. Harris (1994) suggests that truly formative assessment uses the process of assessment to influence and facilitate learning. Mrs. J's use of journal writing as a formative assessment tool did influence her students' mathematical learning to some extent. She regularly

* A similar idea was expressed in Greenwood's thinking criteria number 2, appendix 1.

used journal writing to indicate student understanding of a given concept or procedure and as a prompt to provide further instruction, to correct misunderstandings.

Like Bagley and Gallenberger (1992), Mrs. J stated that it was not possible to read the journal entries without making assessment judgments and that they frequently contributed to her overall assessment of her students in mathematics. Mrs. J considered the journal entries as evidence to support the overall assessment of her students in mathematics (in line with the findings of Borasi and Rose, 1989). After implementing the journal writing programme, and developing the thinking based rubrics, Mrs. J felt a significant increase in confidence in the accuracy and relevance of her assessment of her students in mathematics.

An indication of the extent and significance of change in Mrs. J's assessment of mathematics, influenced by the implementation of the journal writing programme, would have been an observed change in the selection of material for inclusion in the portfolios (Miklo, 1997, Wilde, 1991). This change was not observed during the project period. To the contrary, the only sample of student work in mathematics to be included in the portfolio during this time was a geometric drawing activity in which the students were given specific instructions *not* to write. This may indicate a shortfall in Mrs. J's understanding of what entails a significant journal response and/or in her understanding of how to use journal entries as formal evidence to present growth in student learning in mathematics.

There was, however, a move towards student self-assessment in mathematics. In line with the research of Di Pillo, Sovchik and Moss (1997), Mrs. J recognised that the journal entries themselves were a form of student self-assessment; students thinking about what they know and understand in mathematics. However, other than the entries themselves and the discussions

** In line with Greenwood's thinking criteria number 7.

that followed in sharing sessions, students had no further input into this form of self-assessment. No journal entries were included in portfolios and students were not given an opportunity to have an input into the selection of other mathematical material for inclusion. The teacher's assessment report of the each student's performance in the geometry unit was included, but not the rubric upon which the assessment was based. As such, the potential of the rubric to improve student performance in mathematics was unrealised (Arter & McTighe, 2001). Similarly, the self-assessment version of the same rubric was not included in the portfolio (possibly due to time constraints). Students were not required to give any feedback in response to the teacher's assessment of their performance. The journals provided the only opportunities at this stage for students to record their thinking on how they felt they were doing in maths.

3. To what extent can generic rubrics be used to keep a record of student progress in thinking and communication in mathematics? How much does journal writing contribute to such assessment?

The thinking-based 'mathematics learning criteria assessment' rubric (Appendix 3) focused Mrs. J's attention on student thinking and understanding for assessment purposes. The development of thinking based rubrics also resulted in Mrs. J listing the learning outcomes for a mathematics topic, enabling her to monitor individual student's performances in mathematics. Mrs. J stated that the rubric guided her in what to look for in her students' mathematics, and gave her ideas for prompts. Without guidance, there is potential to miss the significance of students' mathematical responses (Ball & Bass, 2000). However, it is questionable whether the rubric provided enough guidance for Mrs. J as she did not use the related rubric to assess the significance of individual journal entries, nor did she select significant journal entries for inclusion in the portfolio.

While the rubrics were never meant to be the focus of this project, they did become a large part of Mrs. J's assessment in mathematics. Mrs. J played a

major role in the rubric development, using her experience and knowledge of assessment from other areas of the curriculum to determine their format and use. She adapted them to meet her needs by changing the original rubric to include the specific learning outcomes for geometry. Throughout the development and implementation of writing journals in mathematics, and through the use of rubrics that make thinking the focus of mathematical learning, Mrs. J was beginning to bring her assessment of mathematics in line with her practices in other areas of the curriculum. However, without student involvement in the assessment process, this was not going to be fully achieved.

The potential for the rubrics to contribute to student self-assessment in mathematics was evident by the responses of the few students who trialed the self-assessment rubric. Each student interviewed was able to:

- Indicate where they saw themselves on the rubric
- Explain why they thought they fitted a particular description
- Describe a variety of strategies they could employ in future to affect movement up the rubric.

Arter and McTighe (2001) suggest that carefully formulated rubrics, when used collaboratively by teachers and students can improve student performance. The self assessment rubric developed during this project provided significant potential for students to be made aware of their mathematical thinking and learning and for the teacher to recognise significant progress in that learning. As such, the self assessment rubric may have guided both students and teacher in recognising significant journal entries, entries that contributed to the achievement of learning outcomes defined in the rubrics themselves. Unfortunately, due to time constraints, this was never tested.

The rubric to assess individual journal entries was found to be redundant. While there may have been potential for focusing the teacher's attention on the type of prompts she used and the areas individual students struggled or excelled in, Mrs. J found the process of assessing each individual entry against

a thinking-based rubric unnecessary and limiting. Although Mrs. J recorded a scaled assessment for selected journal entries (Appendix 12), she did not use the rubric as a guide. These assessment judgments were grade-based along a seriated scale. It may be that these grades would indicate a pattern or profile of student achievement over time. However, the scaling process was relatively undefined. Mrs. J used a 4 point scale:

1. excellent; exceeds criteria
2. very good; above criteria
3. adequate; within expected criteria
4. experiencing difficulty; below criteria.

These grades were assigned without clear guidelines to define the criteria. As such, Mrs. J ran the risk of attributing grades arbitrarily, influenced by pre-conceived ideas of student performance and ability, rather than as a result of student performance assessed against clearly stated descriptions of criteria for quality work. While Thompson, Thompson and Else (2000) successfully used a similar grading procedure to assess student achievement of mathematical learning criteria along a seriated 3 point scale, they supported this assessment with samples of student writing that provided evidence for their assessment judgments and linked their assessment judgments to clearly defined outcomes.

5.3 Conclusions

This action research project involved the implementation of a mathematics journal writing programme, supported by thinking-based rubrics, in a single class. The impact of this programme on a teacher's (Mrs. J) approach to the teaching and assessment of mathematics was the central focus of the study.

Mrs. J successfully implemented and took ownership of the journal writing programme. It became an integral part of her mathematics class. Use of the journals influenced her teaching and assessment of mathematics. Thinking-based rubrics were developed, using Greenwood's (1993) criteria for mathematical thinking. Mrs. J stated that she used the rubrics to guide and assist her in developing prompts for journal writing. She suggested that the

rubrics helped her to initiate prompts; they helped her think of what she wanted to find out from her students. She believed that the journals and the rubrics supported each other and stated that she used student journal entries as evidence to support her rubric-based assessment of students in mathematics. However, she did not share, or make reference to this evidence during the reporting of her assessment.

Mrs. J used journal writing to determine whether or not, and to what extent, her students understood mathematical content or procedures. She explored student attitudes to mathematics through journal writing and used journal writing to focus student attention on explaining and describing their mathematical thinking. However, Mrs. J did not use journal writing to expand the mathematical thinking of her students as Borasi and Rose (1989) suggested; she did not demonstrate a recognition of significant journal entries or use exposed student thinking to challenge students beyond prescribed learning outcomes.

Journal writing has had an impact on Mrs. J's approach to teaching mathematics and on her approach to mathematics as a subject. The extent of this impact, I suggest is, and will continue to be, limited by the depth and breadth of her own understanding of mathematics.

Chapter 6

Long-term effects of the study

Mrs. J, the collaborating teacher, is a leader of a seven-teacher syndicate. Since the completion of the research section of this project, the school in which she teaches has completed the first semester of a new academic year. During this time, Mrs. J has encouraged and assisted her team to implement journal writing in their mathematics programmes. A few weeks into the semester, she and I collaborated in presenting a 2 hour workshop to the other teachers in the syndicate, outlining how we had started the programme, how Mrs. J managed the programme; how she formulated writing prompts and wrote responses to students, and what we each saw as the benefits of such a programme. We shared successful writing sessions and examples of journal entries we had found useful and revealing. We reviewed Greenwood's criteria for mathematical thinking, discussed how these fitted into the PYP curriculum currently being implemented throughout the school, and left the teachers with a copy of a printout from the website, www.ucs.mun.ca/~mathed/t/rc/jour/, outlining why and how to implement journal writing in mathematics. Since this workshop, all of the teachers have begun journal writing with their classes as part of their regular mathematics programme. While Mrs. J did present the rubrics we had developed, the staff were given the choice of whether or not to use these in collaboration with journal writing. Three of the teachers chose to trial the self-assessment rubric and use the thinking rubric as a guide for prompt writing*.

* The school mathematics scheme was currently under extensive review to bring it in line with PYP directives. Teachers felt the need to wait for the outcome of this before adjusting formal assessment techniques.

6.1 Further research

As with any group of teachers, this syndicate represents a wide range of teaching styles, attitudes and expertise in mathematics. A useful study would be to compare the way each teacher chose to implement, and use, journal writing in their teaching and assessment of mathematics and the impact of these differences on the journal writing programme itself. From this, the following issues for further research are raised:

- The impact of individual teacher's personal strengths and teaching styles on their implementation and use of journal writing in mathematics.
- The relationship between teaching style and categories of prompts used to stimulate student journal writing.
- The relationship between teaching style and style of teacher responses to student journal writing.
- The relationship between teacher expertise in mathematics and the use of writing journals as a teaching tool to extend the mathematical thinking of students.
- Effective ways of supporting the implementation of journal writing in primary mathematics; support that focuses teacher attention on mathematical learning, thinking and understanding rather than just content, and guides teachers in the use of writing journals as teaching and assessment tools in mathematics.

6.2 The contribution of this project to the study of journal writing in mathematics

Borasi and Rose (1989) suggest that there is value in focusing on a specific teaching style as a contribution to the overall picture of how individual teachers can use journal writing in mathematics. Mrs. J represents those elementary teachers who lack confidence and expertise in mathematics, who feel they have become focused on mathematical content, rather than the mathematical learning of their students, and feel they are overly dependant on the textbook.

Mrs. J demonstrated expertise in rubric supported, performance-based assessment techniques in other areas of the curriculum. She was able, with the support of the journal writing programme, to adapt these techniques to her teaching and assessment of mathematics. Others, not so familiar with these techniques might find the frames for mathematical writing, as suggested by Mitchell and Rawson (2000), of greater value.

It is not typical for elementary teachers to posses a deep and broad knowledge of mathematics; few elementary teachers are mathematics specialists. As such, there may be a limit for some teachers to the potential of journal writing to be used as a teaching tool in mathematics. However, regardless of expertise, teaching style or background, writing journals in mathematics have the potential to affect the teaching and assessment of mathematics of any teacher who uses them in their class as a tool to communicate with their students. The mere act of a student being prompted to write what they think or know about a mathematical concept, procedure or idea, will expose the teacher to the thinking of their students that was previously hidden or at least, not easily accessible. Such information provided Mrs. J with feedback about the effectiveness of her teaching and about her students' understanding of given mathematical concepts or procedures. While she struggled to use journal writing to expand student thinking beyond set learning criteria, she frequently used journal writing to identify misunderstandings and misconceptions, enabling her to act accordingly to rectify these. Such knowledge of student understanding, and the resulting opportunities to improve student learning, would most likely have been missed by Mrs. J without the journal writing programme.

Contemporary assessment of mathematics that focuses not only on content knowledge of students, but also their ability to think, reason and explain, suggests that teachers like Mrs. J must look beyond the textbook for their mathematics teaching. Journal writing assisted Mrs. J in doing this. She began to focus on student thinking and explanations in mathematics and

recognise mathematics related problem solving opportunities outside the textbook. Such change in a single teacher's approach to the teaching and assessment of mathematics as demonstrated in this research project should provide inspiration for others to seek change in their teaching and assessment of mathematics through the implementation of a journal writing programme.

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www.ucs.mun.ca/~mathed/t/rc/jour/journal.htm (down loaded 19.4.2001, author unspecified) *Mathematics journals: Implementing a journal writing programme in mathematics class.*

Appendix Contents

Greenwood's criteria for mathematical thinking

1

Everything you do in mathematics should make sense to you.

2

Whenever you get stuck, you should be able to use what you know to get yourself unstuck.

3

You should be able to identify errors in answers, in the use of materials and in thinking.

4

Whenever you do a computation, you should use a minimum of counting.

5

You should be able to perform calculations with a minimum of rote pencil-paper computations.

6

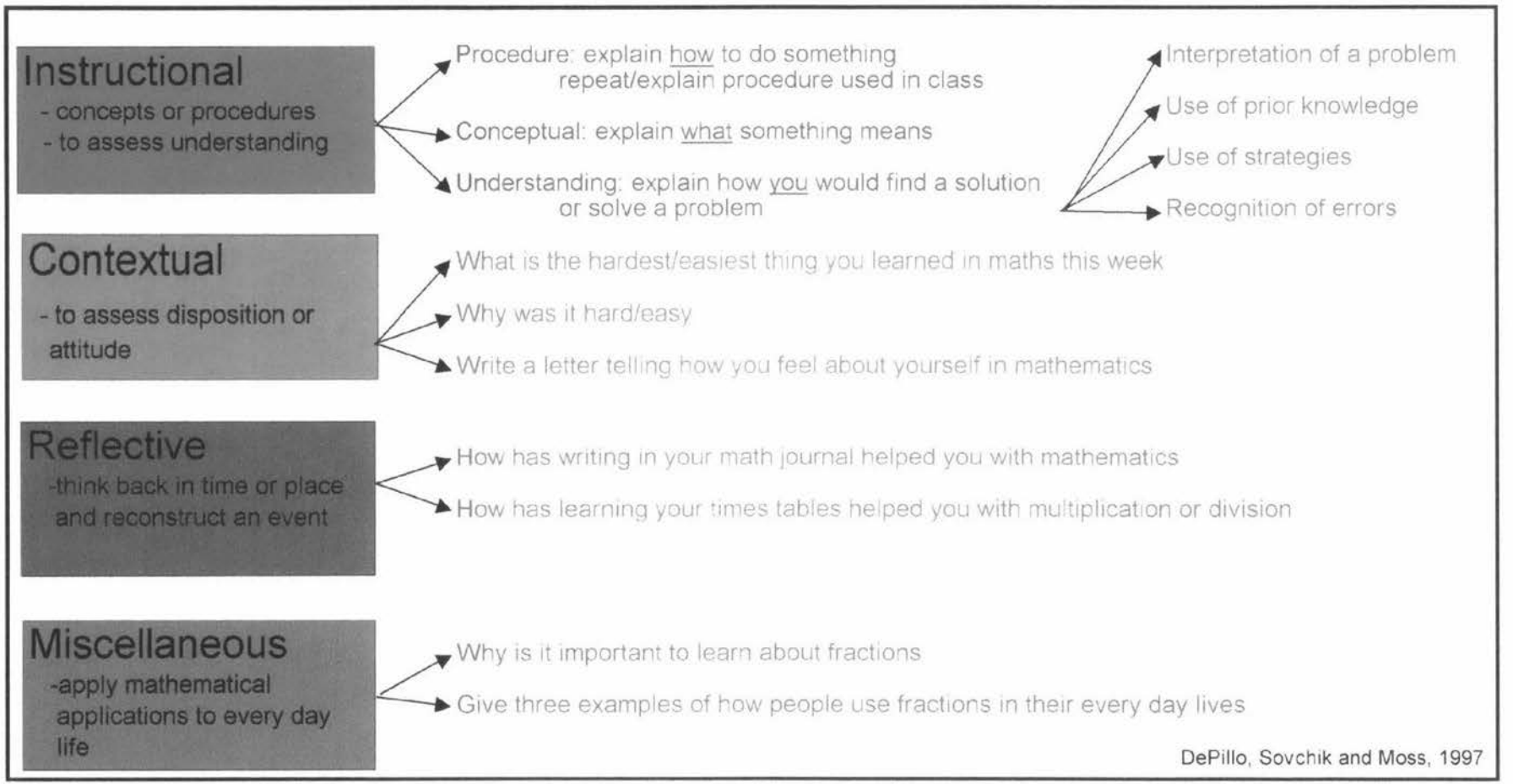
When the strategy you are using isn't working, you should be willing to try another strategy instead of giving up.

7

You should be able to extend, or change, a problem situation by posing additional conditions or questions.

J.J. Greenwood, 1993.
On the nature of teaching and assessing "mathematical power" and "mathematical thinking".
Arithmetic Teacher, November 1993.

Prompts for writing journals in mathematics



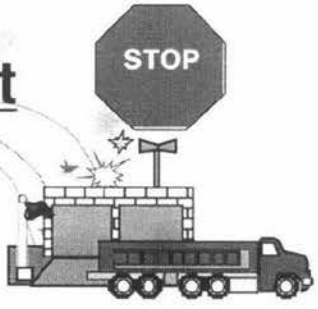
Mathematics Learning Criteria Assessment

Levels	Communicating ideas	Strategy use	Computations	Attitude/ Aptitude	Topic Work Learning Outcomes
1 **Exceeds criteria** **Excellent** **Working well above grade level**	*Usually produces work with a high level of accuracy *High level of clarity *Clearly understands concepts *Thoroughly explains strategies *Usually explains reasons for choice of strategy *usually recognises errors	*Regularly constructs and selects appropriate strategies independently *Usually recognises errors independently and alters strategies accordingly *Perseveres with a variety of strategies rather than giving up	*Recalls basic facts quickly *Accurately manipulates computations mentally, requiring a minimum of counting *Able to verbalise these mental manipulations clearly	*great *totally positive *excited *challenged *very confident	*totally accurate *clearly understands concepts *able to apply concept to new situations independently *able to explain concept thoroughly and provide examples *questions and explores beyond the expected learning outcome
2 **Above criteria** **Very good** **Working above grade level**	*Is often accurate *Good level of clarity *Good understanding of concepts *Can explain strategies used *Often explains reasons for the choice of strategies used *Recognises errors	*Generally considers appropriateness of strategy choices *Generally recognises errors *Attempts alternative strategies but may require teacher assistance eventually	*Recalls most required basic facts *Groups and manipulates numbers for faster computation to some degree, mentally or on paper *Able to discuss these manipulations	*good *positive *aware of improvements in own learning *confident	*fairly accurate *good understanding of concepts *able to explain concepts *able to apply concepts to new situations with a minimum of teacher prompting
3 **Approaches criteria** **Adequate** **Working at grade level**	*Not always accurate *Sometimes confused in thinking *Concepts not always clearly understood *Sometimes explains strategies *May include unrecognised errors	*Generally lacks consideration for appropriateness of strategy choice, tends to follow a learned process *Sometimes requires teacher assistance to recognise errors and adjust strategies *Does not generally attempt alternative strategies independently	*Recalls some basic facts but often uses counting methods *Generally writes computations out in full and solves them long hand *Willing to use number grouping or manipulations for faster computation but generally requires assistance from the teacher to do so	*OK *generally positive *raises some concerns about own learning *not always confident	*fairly accurate *concepts mostly understood *able to explain concepts to some degree *able to demonstrate application of concepts with teacher guidance
4 **Below criteria** **Experiencing difficulty** **Working below grade level**	*Rarely accurate *Often confused *Low understanding of concepts *Regularly and significantly misinterprets task requirements	*Consistently applies inappropriate strategies *Consistently requires teacher assistance to recognise errors and alter strategies *Generally gives up, does not apply alternative strategies independently	*Limited recall of basic facts regularly uses counting methods *Consistently makes errors in computation, often unrecognised *Regularly requires teacher assistance	*poor *negative *either unconcerned with, or unaware of, own needs in mathematics *lacking confidence	*inaccurate *confused *tasks misinterpreted *unable to explain concepts *unable to demonstrate application of concepts even with teacher assistance

ENQUIRY BASED LEARNING CRITERIA ASSESSMENT

Levels	Work Habits	Research Skills	Presentation Skills	Subject Knowledge
ONE exceeds criteria excellent	*always on task *uses time efficiently *serious about work *works independently *minimal supervision *maximum effort *well organised	*able to sort ideas *identifies keywords *asks good questions *plans work according to tasks and time *locates and uses suitable resources *uses own words	*presents information in a logical way *information is varied and clearly relevant *creative presentation *can match presentation to an audience *reaches conclusions *polished and effective	*can give additional information *can clarify / explain points *shows understanding of objectives *gained new insights into topic *answers Qs. easily
TWO above criteria very good	*usually on task *satisfactory use of time *serious about work *works independently *well organised *needs few reminders	*able to sort ideas * identifies keywords *asks good questions *plans research * usually locates & uses suitable resources *uses own words	*information is logical *questions adequately answered *some creativity evident *conveys message *some conclusions *mostly polished and effective	*answers questions *gives additional information *partly clarifies / explains points *shows real not memorised knowledge
THREE reaches criteria good	*frequently on task *some time wasted *serious about work *needs supervision *more effort needed *needs reminders *usually careful	*brainstorms ideas *identifies keywords *asks some good questions *plans research *note takes *uses own words but needs some teacher assistance	*information is logical *questions briefly answered *some rough spots in presentation *information sometimes unclear	*answers some questions *some clarification of points *some additional information given *some information memorised
FOUR approaches criteria adequate	*often on task *some time wasted *more effort needed *needs prompting *could be better organised	*brainstorms ideas *has some keywords *few good questions *needs help with planning *needs help locating resources *some note taking	*some questions answered *some relevance evident *adequate headings *contains some errors *weak areas in presentation *not adequately matched to audience	*adequate answers to questions *trouble explaining and clarifying points *needs more information *memorises material
FIVE partially meets criteria needs improvement	*sometimes on task *time often wasted *not serious enough about work *often needs prompting *more effort needed *needs to be organised	*limited brainstorming *has few keywords *few good questions *needs help with planning *needs help locating resources *poor note taking *copies material	*information is vague *lacks basic information *headings are inadequate *contains errors *weak areas in presentation	*can't extend beyond memorised material *poor or no answers to questions *trouble explaining and clarifying points
SIX below criteria experiencing difficulty	*rarely on task *time often wasted *little or no effort *needs constant supervision *poorly organised	*can't brainstorm *poor questions *needs help with planning *can't locate/use resources *copies material	*information does not answer questions *contains no conclusions *disorganised *difficult to read *presentation does not match audience *information is not relevant	*unable to answer questions *no additional information *poor understanding of topic

Sound Study Marking Sheet



NAME: _____ GRADE: _____

CRITERIA	LEVEL	COMMENT
WORK HABITS		
PLANNING		
INFORMATION SKILLS		
WRITTEN PRESENTATION		
KNOWLEDGE OF TOPIC		
ORAL PRESENTATION		

GENERAL COMMENT:

Mathematics Learning Criteria Assessment – Geometry G3

Levels	Communicating ideas	Strategy use	Computations	Attitude/ Aptitude	Topic Work Learning Outcomes
1 Exceeds criteria Excellent Working well above grad level	*Usually produces work with a high level of accuracy *High level of clarity *Clearly understands concepts *Thoroughly explains strategi *Usually explains reasons for choice of strategy *usually recognises errors	*Regularly constructs and selects appropriate strategies independently *Usually recognises errors independently and alters strategies accordingly *Perseveres with a variety of strategies rather than give up	*Recalls basic facts quickly * Accurately manipulates computations mentally, requiring a minimum of counting * Able to verbalise these mental manipulations clearly	*great *totally positive *excited *challenged *very confident	• easily classifies geometric shapes & objects according to attributes • confidently uses geometric terminology • Easily identifies and describes types of angles • Understands and uses angles as a measure of rotation
2 Above criteria Very good Working above grade lev	*Is often accurate *Good level of clarity *Good understanding of concepts *Can explain strategies used *Often explains reasons for the choice of strategies used *Recognises errors	*Generally considers appropriateness of strategy choices *Generally recognises errors * Attempts alternative strategies but may require teacher assistance eventually	*Recalls most required basic facts *Groups and manipulates numbers for faster computation to some degree, mentally or on paper * Able to discuss these manipulations	*good *positive *aware of improvements in own learning *confident	• Classifies most geo shapes & objects according to attributes • usually uses geo terminology • able to identify & describe most type of angles • usually understands & uses angles as a measure of rotation
3 Approaches criteria Adequate Working at grade level	*Not always accurate *Sometimes confused in thinki *Concepts not always clearly understood *Sometimes explains strategies *May include unrecognised errors	*Generally lacks consideration for appropriateness of strategy choice, tends to follow learned process *Sometimes requires teacher assistance to recognise errors and adjust strategies *Does not generally attempt alternative strategies independently	*Recalls some basic facts but often uses counting methods *Generally writes computations out in full and solves them long hand *Willing to use number groupi or manipulations for faster computation but generally requires assistance from the teacher to do so	*OK *generally positive *raises some concerns about own learning *not always confident	• classifies some geo shapes & objects according to attributes • uses some geo terminology • identifies & describes some types of angles • needs some help to understand & measure angle rotation
4 Below criteria Experiencing difficulty Working below grade lev	*Rarely accurate *Often confused *Low understanding of concep *Regularly and significantly misinterprets task requirements	*Consistently applies inappropriate strategies *Consistently requires teacher assistance to recognise errors and alter strategies *Generally gives up rather than apply alternative strategies	*Limited recall of basic facts regularly uses counting methods *Consistently makes errors in computation, often unrecognised *Regularly requires teacher assistance	*poor *negative *either unconcerned with or unaware of own needs in mathematics *lacking confidence	• classifies few geo shapes & objects according to attributes • unable to use geo terminology • struggles to identify types of angles • struggles to measure angle rotation

Writing Journal Rubric

Levels	Communicating ideas	Strategy use	Computations	Attitude/ Aptitude	Topic Work Learning Outcomes
1 **Exceeds criteria** **Excellent** **Working well above grade level**	* totally clear * strategies thoroughly explained * recognised and acted upon any errors	* consciously selected appropriate strategy and explained choice * may have successfully constructed a unique strategy * persevered with a variety of alternative strategies independently	* instant recall of basic facts * thoroughly accurate * outstanding manipulation of numbers, minimising computation	* great * totally positive * excited * challenged * very confident	* totally accurate * clearly understands concept
2 **Above criteria** **Very good** **Working above grade level**	* fairly clear * strategy mostly explained * recognised any errors	* demonstrates consideration of strategy choice * able to explain reasons for strategy choice * may have attempted alternative strategies independently	* good recall of basic facts * fairly accurate * some number manipulation evident	* good * positive * aware of improvements in own learning * confident	* fairly accurate * good understanding of concept
3 **Approaches criteria** **Adequate** **Working at grade level**	* maybe a little unclear * strategy mentioned but not fully explain * may include unrecognised errors	* learned process followed without apparent consideration for appropriateness of strategy choice * unable to explain reasons for strategy choice clearly * required teacher intervention to alter strategy choices	* limited use of recalled basic facts * may include some errors * generally solved long-hand without apparent consideration of number manipulation	* OK * generally positive about own learning * not completely confident	* fairly accurate * concept mostly understood
4 **Below criteria** **Experiencing difficulty** **Working below grade level**	* confused * unclear * task misinterpreted	* inappropriate strategy applied without apparent recognition * unable to explain strategy choice * had difficulty altering strategy even after teacher intervention	* inaccurate * confused	* poor * negative * either unconcerned with or unaware of own needs in mathematics * lacking confidence	* inaccurate * confused * task misinterpreted

Writing Journal Record

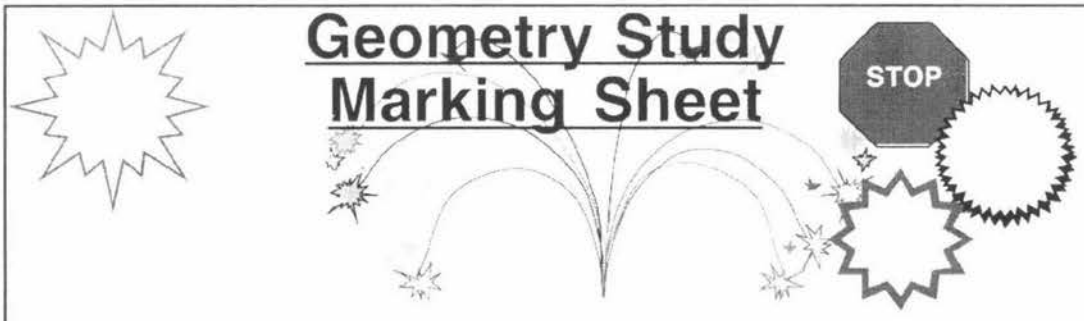
Possible criteria	Attitude	multiple methods to Xn. Communication	communication	strategy	Computation	Computation	24÷_ = 3 communication	TOPIC create a text	attitude	strategy	TOPIC Pattern Recognition	attitude/ aptitude	TOPIC create a context	TOPIC create a context	AVERAGE communication
Date	1/12	30/1 →		31/1	6/2	6/2 →		13/2	16/2	20/2	27/2 →		28/2	2/3	7/3
Hellen	1				✓	3	2	2	1	1	1	1	3	3	2-
Nora	·	esc	3		✓	3+	3+		3-	3	2	3+	4	4	3
Hedd	1	2+	2	3	✓	2+	1	3	2	2	2	2	2	1	1
Sian	3	2-	3		✓	3+	2	3	2	2	2	2	3-	1	3
Julia	2	3+	3	3	✓	4	4	2	3+	3-	2	3	3	4	3+
Tuulimaria															
Tessa	·	3	·		·	2	3	3-	3	3-	3	3+	3-	2	4+
Shin Hye	2	3	3	4	✓	3	3	3	3-	3+	2	2	2	4	2
Lauren	·	3	3		✓	3	3	3-	2+	3	·	2	2	1	2+
Sasha	2-	3-	3		✓	3	3	3+	2+	4	3	3	3	2	2
Adam	2	2+	2	2	✓	1	1	1	2-	1	1	1	1	1	2+
Michael	2	2-	·		✓	3	3	3+	2-	2	2	2	a	a	3
Eugene	2	3-	2		✓	3+	3+	4	1	2	·	2	a	4	3-
Erik	·	2	3		✓	2	3+	2	2	3-	2	2	2	1	3
Kevin	·	3	2		✓	3	3	1	2-	3	·	2	1	2	2
Edward	1	2+	2	3	a	2	2	2	1-	3+	·	2	2	1	2
Chris	2-	3+	3+		3	4/3	3	3+	2	3	2	1	1	1	3+
Mitchell	3	4	4		✓	3	3	4	2	3-	4	3	4	?	3
Anthony	1	3	2	3-	2	3	3	2	1	3	2	1	2	3	1
David	1	2	2+		✓	3	3	3-	2	2	2+	2	2	1	2
Marshal															

1 Excellent, exceeds criteria
2 Very good, above criteria
3 Adequate, within criteria
4 Experiencing difficulty, below criteria

· Participated but assessment unable to be made
a absent

Appendix 8

Geometry Study Marking Sheet



NAME: _____ GRADE: _____

CRITERIA	LEVEL	COMMENT
Communicating Ideas		
Strategy Use		
Computations		
Attitude / Aptitude		
Classifying Shapes		
Using Angles		

GENERAL COMMENT:

How Am I Doing In Maths?

Levels	Communicating ideas	Strategy use	Computations	How I feel about maths	Topic Work
1 **Exceeds criteria** **Excellent** **Working well above grade level**	* I can explain exactly what I do and think in maths and why I choose to do things that way.	* If I make a mistake, I usually keep trying lots of different ways until I fix the mistake myself. If I still can't fix it, I get help.	* I remember basic facts really quickly. * I have lots of tricks and short cuts for solving equations quickly. * I am really good at grouping numbers together.		* I understood this topic really well. * I found the work in this topic to be very easy.
2 **Above criteria** **Very good** **Working above grade level**	* I can explain what I do in maths but I sometimes have trouble explaining why.	* If I make a mistake I usually try a different way to fix it myself and then I get help.	* I'm pretty good at remembering basic facts and sometimes use tricks to solve equations in my head.		* I understood most of this topic. * I found most of the work in this topic to be quite easy.
3 **Approaches criteria** **Adequate** **Working at grade level**	* I try hard to explain what I do in maths but I usually have trouble explaining what I think and why.	* If I make a mistake I usually try the same method again and then get help if it's still wrong. * I don't usually try a different method unless someone tells me to.	* I am getting better at remembering my basic facts, but I still usually like to use pencil and paper, my fingers, a calculator, or charts to help me solve equations.		* I understood some of the things in this topic bit there are still some things I'm not sure of.
4 **Below criteria** **Experiencing difficulty** **Working below grade level**	* I find it really difficult to explain what I do in maths because I usually don't really understand it.	* I usually don't notice my mistakes myself, someone has to show me.	* I have trouble remembering basic facts and solving equations even when I use pencil and paper, my fingers, a calculator or charts.		* I don't think I understood enough of this topic. * There are still a lot of things I don't understand.

Questions for Mrs. J

1. Is there a particular category (or categories) of student who you feel particularly benefit from the exercise of writing in mathematics journals?

2. Is there a particular category (or categories) of student who you feel you learn more about by reading their journal entries?

3. How often do you directly follow up with an individual student as a result of a journal entry?

4. How often (as a %) do you plan a follow up session for a group or the full class in the form of a full lesson, a discussion, or questioning for clarification or further explanation?

5. How much (as a %) do the children's journal entries contribute to your assessment of the student's learning in mathematics?

6. How much extra information about a student's learning or understanding of mathematics do you think you gleam from their journal entries?

7. How much (as a %) do the children's journal entries contribute to your planning of the next lesson?

8. List and explain the ways in which you think your mathematics programme may have been affected by journal writing.

9. List and explain any concerns you have about journal writing in mathematics.

10. List the reasons why you might encourage others to implement a journal writing programme in mathematics.

Writing Journal Record

Possible criteria	Problem Solving	Applying Maths	Understanding Concepts	Reflective	Reflective	Understanding concepts																		
Date	28/4	11/4	8/4	17/5	23/5	5/6																		
Hellen	2	1	1	1	1	2																		
Nora	4	3	2	3	3	3																		
Hedd	2	2	2	2	3	3																		
Sian	3	3	2	3	3	3																		
Julia	4	3	2	3	4	4																		
Tuulimaria	3	2	2	3	3	3																		
Tessa	3	2	2	3	3	4																		
Shin Hye	3	2	2	2	2	3																		
Lauren	1	3	2	2	2	3																		
Sasha	3	3	2	3	3	3																		
Adam	3	2	1	1	1	1																		
Michael	4	3	2	2	2	3																		
Eugene	2	1	3	2	2	2																		
Erik	3	2	2	2	2	3																		
Kevin	2	1	1	1	1	2																		
Edward	1	1	1	1	1	1																		
Chris	2	3	2	2	2	2																		
Mitchell	4	2	3	3	3	4																		
Anthony	1	3	2	1	1	1																		
David	1	3	1	1	1	1																		
Marshal				3	3	3																		

1 Excellent, exceeds criteria
2 Very good, above criteria
3 Adequate, within expected criteria
4 Experiencing difficulty, below criteria