

THE EFFECT OF JOURNAL WRITING
IN MATHEMATICS CLASS
ON STUDENTS' BELIEFS

BY

PAMELA L. HOLENS

52

A thesis
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in Partial Fulfilment of the Requirements
for the Degree of

MASTER OF EDUCATION

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Abstract

This study investigated the effects of implementing regular journal writing exercises in mathematics class. Specifically, the study examined the effect of journal writing on students' beliefs, and sought to determine what types of beliefs would be affected. A Likert-type questionnaire was developed to assess students' beliefs in four different categories. The categories were: 1) beliefs about the nature of mathematics, 2) beliefs about the individual as a learner of mathematics, 3) beliefs about the culture of the mathematics classroom, and 4) beliefs about how mathematics is best learned. Five different classes were involved in the study, and students in these classes were given the questionnaire before journal writing was implemented, and again after they had completed five months of regular journal writing. The questionnaire which was given after the journal writing took place also included an open-ended question which asked students to indicate their overall feelings about journal writing in math class.

On 3 of the 34 questionnaire items, a significant change in the mean values occurred between the *before* and the *after* questionnaire, with the greatest change occurring on the item "I have some degree of personal contact with my mathematics teacher". Mean scores on each of the four scales examined as a whole indicated no significant changes on the first analysis. However, a subsidiary analysis was done in which one class was omitted from the sample because regular journal writing had not occurred in this class. With the omission of this class, the analysis showed that a significant change had occurred on the "Culture of the Mathematics Classroom" scale. Examination of students' responses to the open-ended question indicated a generally positive reaction to the journal writing, with numerous responses indicating an appreciation of the increased communication between student and teacher.

Table of Contents

<i>Chapter One - Introduction</i>	8
Purpose of the Study	9
Rationale for the Study	10
Hypothesis	11
Limitations of the Study	11
Significance of the Study	12
<i>Chapter Two - Review of the Literature</i>	13
Defining Beliefs	13
Culture and Beliefs	15
Students' Beliefs	16
The Nature of Mathematics	17
The Individual as a Learner of Mathematics	17
The Culture of the Mathematics Classroom	18
How Mathematics is Best Learned	19
Journal Writing	20
Summary of the Review of the Literature	22
<i>Chapter Three - Method and Procedures</i>	23
The Subjects	23
Instrumentation	24
Instructional Procedure	25
Procedure	26
Interpretation of the Data	26
<i>Chapter Four - Analysis of the Data</i>	28
Individual Scale Items	28

The Scales as a Whole	35
Teacher Survey Information	36
Open Ended Questions for Students	43
Subsidiary Analysis of the Data	49
Summary of the Analysis of the Data	50
Chapter Five - Summary, Conclusions, and Recommendations	51
Summary of the Study	51
Questions and Procedures	51
Results	51
Implications of the Results	52
Recommendations for Further Research	53
Conclusions	54
References	55
Appendix A - Letters to Principals and School Divisions	60
Appendix B - Letter from School Division	65
Appendix C - Letter to Parents	67
Appendix D - Journal Writing Topics Given to Teachers	69
Appendix E - The Scales	72
Appendix F - The Instrument	75
Appendix G - Follow-up Survey Given to Teachers	80

List of Tables

Table 1 - Scale: The Nature of Mathematics	
Itemized Results	29
Table 2 - Scale: The Individual as a Learner of Mathematics	
Itemized Results	31
Table 3 - Scale: The Culture of the Mathematics Classroom	
Itemized Results	32
Table 4 - Scale: How Mathematics is Best Learned	
Itemized Results	34
Table 5 - Analysis of Difference in Whole Scale Means Before and After	
Results for Full Data Set	35
Table 6 - Analysis of Difference in Whole Scale Means Before and After	
Results Excluding Class A	49

List of Figures

Figure 1 - Journal Writing Topics Used by Teachers 37
Figure 2 - Student Responses to Open-ended Question 44

Chapter One

INTRODUCTION

There is a growing consensus among both educators and non-educators alike that the methods and practices of teaching which are used in today's classrooms are not meeting the needs of today's students or today's society. More and more, students are feeling completely disconnected from almost everything they are asked to do in classrooms (Wagner, 1993). Over the course of the last 30 years, our economy has changed dramatically. No longer is ours a society in which most people earn their living with skilled hands. Rather, it is shifting towards a society in which, increasingly, people must use their skilled intellect to earn a living (Wagner, 1993). Our classrooms and teaching practices must reflect this change.

In their 1989 document Curriculum and Evaluation Standards for School Mathematics (Standards), the National Council of Teachers of Mathematics recognized this shift in our society and the resulting need for change in the methods and practices of teaching mathematics. The Standards suggest that schools, as they are now organized, are a product of the industrial age, and that the educational system of the industrial age does not meet the economic needs of today's information society. In order to meet these needs, today's schools must "insure that all students have an opportunity to become mathematically literate, are capable of extending their learning, have an equal opportunity to learn, and become informed citizens capable of understanding issues in a technological society" (NCTM, 1989, p. 5).

Beyond the economic arguments for change, current research on students' learning processes also suggests the need for change in teaching practices. The research indicates that most students cannot learn mathematics effectively by simply listening and imitating,

rather they need to be given the opportunity to construct their own understandings through personal intellectual engagement with mathematics concepts (Everybody Counts, National Research Council, 1989).

Efforts to reform mathematics curriculum and instruction across North America are increasingly looking to the Standards document for guidance. One critical feature of the Standards is the focus that it puts on affective issues. Two of its five general goals for all mathematics students are affective in nature. These goals include learning to value mathematics, and becoming confident in one's own ability. Similarly, the National Research Council's (1989) report on the future of mathematics education (Everybody Counts) puts a great deal of emphasis on affective issues such as the need to change the public's beliefs and attitudes about mathematics.

According to McLeod (1992) this increased emphasis on affective issues is related to the importance that the reform movement places on higher-order thinking. He states, "If students are going to be active learners of mathematics who willingly attack nonroutine problems, their affective responses to mathematics are going to be much more intense than if they are merely expected to achieve satisfactory levels of performance in low-level computational skills" (1989, p. 575). Consequently, any effort to effect lasting changes in curriculum and instructional practices in mathematics, such as those outlined in the Standards will have to take affective issues into account if it is to succeed.

Purpose of the Study

Affective issues are closely connected to the vision of reform indicated in the Standards. Not only will affective issues play a role in the success or failure of such a reform movement, but affective issues themselves are addressed in the Standards as a key element in need of reform in mathematics education. The term *affect* is generally considered to encompass several different components, one of which is beliefs (Simon, 1982). In this

study, students' beliefs, as one component of affect, will be examined. Specifically, a change in instructional practices in the mathematics classroom will be employed in an effort to impact on students' beliefs. The change in instructional practices will be the implementation of regular journal writing exercises. Accordingly, this study will seek to answer the following two questions:

1. Will the implementation of regular journal writing exercises in the mathematics classroom have any effect on students' beliefs about mathematics?
2. What types of beliefs will be affected by such a change?

Writing exercises such as those to be used in this study are among the many suggestions for improving instruction which can be found in the Standards document.

Rationale for the Study

If the goals of the NCTM Standards (1989) are to be realized, affective issues such as students' beliefs about mathematics will have to be given serious consideration. According to Kloosterman and Stage (1992), many students hold beliefs which actually hinder their interest in, and understanding of, the subject of mathematics. Similarly, Silver (1985) points out that certain beliefs that students hold about mathematics may in fact weaken their ability to solve nonroutine problems. Yet improving students' ability to solve nonroutine problems is one of the central goals of the Standards. The issue then becomes a question of what is causing students to develop these destructive beliefs, and whether or not it is possible for teachers to affect these beliefs in a positive way.

Two important researchers in the area of beliefs are Mandler and Schoenfeld. Schoenfeld (1988) contends that the problem does not lie in the students' mechanisms for developing beliefs, but rather in the curriculum and culture which encourage such beliefs. Mandler (1984, 1989) also indicates the importance of examining the culture which shapes students' beliefs.

Hypothesis

Given that the culture to which a student is exposed greatly influences the types of beliefs the student will acquire, a change in this culture should create a subsequent change in the student's beliefs. The culture used to affect change in this study will be the culture of the mathematics classroom, and the agent of change will be the implementation of regular journal writing exercises in the mathematics classes.

With this hypothesis in mind, it must also be recognized that significant change is never easy to achieve. As Donahoe (1993) suggests, culture is not something which can be changed like a flat tire. Rather it is organic to its community. He quotes psychoanalyst Allen Wheelis as saying, "We are wise to believe it difficult to change, to recognize that character has a forward propulsion which tends to carry it unaltered into the future, but we need not believe it impossible to change."

Limitations of the Study

This study will be limited by a number of factors. One such factor is that it will be impossible to determine whether any changes that are realized over the time period of the study can in fact be directly attributed to the practice of journal writing. It is possible for numerous other factors to affect students' beliefs during that same time period.

Another limiting factor is the duration of time over which the study will take place. Five months may not be long enough to significantly influence students' beliefs, especially considering the fact that beliefs are generally strongly rooted and thus difficult to change.

A final limiting factor is the variability among the teachers involved in the study in terms of how they individually implement the journal writing exercises. There will be variations in how often they expect students to write in their journals, how much emphasis and importance they give to the journal writing, and whether or not they follow up the

journal writing exercises with whole class discussions of the issues involved in each particular writing exercise.

Significance of the Study

Increasingly, attention has been given to the study of affective issues, such as students' beliefs about mathematics. However, most of this attention has been in the form of quantitative studies designed to measure what types of beliefs students hold. Relatively little has been done from a more experimental perspective in an effort to determine what types of variables affect what students believe, and how students' destructive beliefs can be influenced to become more productive in nature. This study will take the experimental perspective in examining an instructional practice suggested by the Standards. If teachers are to whole-heartedly jump on the band wagon of new ideas suggested by both the Standards and by forthcoming curriculum changes, they will want evidence that these new instructional practices are effective, and that they do in fact bring students closer to the affective goals indicated in the Standards document. This study may give teachers some of the evidence they need to help them accept the forthcoming wave of reform.

Chapter Two

REVIEW OF THE LITERATURE

The review of the related literature has been organized into five sections. The first section deals with defining beliefs. The next section deals with the impact of culture on beliefs. In the third section, the beliefs held by students will be examined. Literature on journal writing will be the focus of the fourth section. Finally, a summary of the literature will be provided in the fifth section.

Defining Beliefs

Part of the difficulty in doing a study that involves affective components such as beliefs is in dealing with the numerous conflicting definitions which can be found in the literature. As Hart (1989) and Simon (1982) note, affective terms sometimes have different meanings in psychology than they do in education. Even within the same field, studies which use identical terminology are often not actually studying the same phenomenon. According to McLeod, "Clarification of terminology for the affective domain remains a major task for researchers" (1992, p. 576).

In looking at the use of the term "belief" in the literature, one finds Colby (1973), who indicates that beliefs are "non-observable relations in human behaviour". Other researchers have since defined the term with more precision. Wyer (1974), for example, defines beliefs by equating the concept with attitudes. Taking the definition a step further, Rajecki (1982) defines beliefs as one of three *components* of attitude. The three components of attitude which Rajecki describes are: 1) an affective or emotional response to the object, 2) behaviour toward the object, and 3) beliefs about the object. An alternative view is taken by Simon (1982), who in fact makes a definite distinction *between* beliefs

and attitudes. He uses the more general term *affect*, which he describes as a term that encompasses three distinct concepts. These related but distinct concepts are: 1) beliefs, 2) attitudes, and 3) emotions. According to Hart (1989) this is the manner in which educators generally use the term affect.

McLeod's (1992) review of the research on affect in mathematics education separates affect into these same three components. McLeod distinguishes between the three terms by the degree of affective and cognitive involvement each entails. According to McLeod, on the scale from emotions to attitudes to beliefs, emotions entail the highest degree of affective involvement, while beliefs entail the highest degree of cognitive involvement. He states that "Beliefs are largely cognitive in nature and are developed over a relatively long period of time" (1992, p. 579). In a table of examples distinguishing between beliefs, attitudes, and emotions, McLeod characterizes emotions with words like "joy" and "frustration". He characterizes attitudes with words like "dislike of" and "enjoyment of". In characterizing beliefs, he uses words like "is", "are", and "am" which imply a greater degree of cognitive evaluation.

McLeod bases his distinction between beliefs, attitudes, and emotions primarily on the work of Mandler (1984, 1989), a leading cognitive psychologist. Coming from the perspective of cognitive psychology, Mandler's theory attempts to incorporate affective factors into cognitive theories. His theory suggests that affective factors such as beliefs, attitudes, and emotions arise out of emotional responses to interruption of plans or planned behaviour. The interruption is evaluated by the individual, and this evaluation gives meaning to the arousal which has occurred. How the interruption is evaluated will depend on the individual's existing knowledge and *beliefs*. Arousals such as this are generally of short duration, and have a fairly strong response intensity, which would place them in the category of *emotions*. If repeated interruptions occur in a similar context, the intensity of

the response will decrease, but will become more stable. At this stage the formation of *attitude* has begun. Continued interruptions in the same context may in fact alter the beliefs that the individual holds.

There seems to be agreement among a number of leading researchers (Simon, 1982; Mandler, 1984, 1989; McLeod, 1992) that the concepts of emotions, attitudes, and beliefs, are interrelated, but indeed distinct. This study will thus adopt the conceptual framework of these researchers. Accordingly, beliefs will be taken to be the construct which entails the least amount of emotional involvement and the greatest amount of cognitive involvement. Belief statements on the questionnaire to be used in this study will thus make use of terms like “is”, “are”, and “am” as suggested by McLeod’s (1992) distinctive examples.

Culture and Beliefs

Beliefs and culture are intricately connected concepts. Donahoe sees beliefs as a part of what defines culture. He indicates that culture is “the values, beliefs, behaviours, rules, products, signs, and symbols that bind us together” (1993, p. 302). Similarly, Tylor (1871) defines culture, taken in its wide ethnographic sense as “that complex whole which includes knowledge, belief, art, morals, law, customs, and any other capabilities and habits acquired by man as a member of society” (p. 1). These definitions indicate that beliefs are a part of what is meant by the term culture.

While beliefs can be seen as one component of what comprises culture, they may also be seen as concepts which are moulded *by* culture. Schoenfeld (1988), in examining students’ beliefs as they relate to ineffective problem solving behaviour, contends that the problem does not lie in the students’ mechanisms for developing beliefs, but rather in the curriculum and culture which encourage such beliefs. McLeod (1992) shares this

perception that culture shapes beliefs. Similarly, Mandler (1984) states that culture is a powerful teacher of evaluative judgments, primarily through the vehicle of the common language. Mandler (1984, 1989) also indicates the importance of examining the culture which shapes students' beliefs.

The main hypothesis of this study is supported by the fact that culture and beliefs are intricately connected. To restate the hypothesis, if the culture that a student is exposed to influences the sorts of beliefs that student will acquire, then a change in the culture should create a subsequent change in the student's beliefs. The culture referred to in this study is not the larger, societal culture, but more specifically, the culture of the mathematics classroom. Bishop (1991) indicates that "the teacher and the classroom group mould . . . the values which the individual child will receive concerning mathematics. Through activities... the child becomes enculturated into ways of thinking, behaving, feeling and valuing" (p. 15). Bishop also suggests that, although we must not lose sight of the constraints set by society, the institution, and the cultural values carried by mathematics itself, the classroom participants are arguably the most significant shapers of values.

Students' Beliefs

Students' beliefs about mathematics can be placed into many different categories. In this study, four categories of beliefs are examined in an effort to determine some of the types of beliefs that may be affected by the implementation of journal writing. Specifically, the categories of beliefs to be examined are students' beliefs about: 1) the nature of mathematics, 2) the individual as a learner of mathematics, 3) the culture of the mathematics classroom, and 4) how mathematics is best learned. Accordingly, this section will be divided into four sub-sections, each of which will examine one of these four belief categories.

The Nature of Mathematics

The first major belief category to be examined in this study is that of students' beliefs about the nature of mathematics. Carpenter et al. (1983) stated that, according to the Third National Assessment of Educational Progress, students felt very strongly that mathematics always gives a rule to follow in order to solve problems (Schoenfeld, 1989). The 1988 National Assessment of Educational Progress also indicated that students believe that mathematics is based on rules, and that mathematics is both important and difficult (Kloosterman and Stage, 1992). Buerck (1985) similarly observed that many people both in and out of the mathematics classroom believe that mathematics is made up only of rules, formulae, and proofs to be memorized; skills to be practiced; and methods to be followed precisely. Carpenter et al. (1983) also stated that almost half of all mathematics students view mathematics as mostly memorizing. Buerck (1985) commented that people in general tend to believe that mathematics is a discipline in which certainty is secure, and in which all questions have answers that are known to the authorities on such matters.

According to psychologist William G. Perry, Jr. (1970, 1981), this conception of knowledge is called "dualistic". Perry defines dualism as: "Division of meaning into two realms - Good versus Bad, Right versus Wrong, We versus They, All that is not Success is Failure, and the like. Right answers exist somewhere for every problem, and the authorities know them." This dualistic conception of the nature of mathematics will be studied as the first of the four major belief categories, under the heading "*Students' Beliefs about the Nature of Mathematics*".

The Individual as a Learner of Mathematics

The second major belief category to be studied is that of students' beliefs about themselves as individual learners of mathematics. According to the NCTM Curriculum and Evaluation Standards (1989), students' beliefs exert a powerful influence on students'

evaluation of their own ability, on their willingness to engage in mathematical tasks, and on their ultimate mathematical disposition. McCombs (1986) stated that one's beliefs about oneself, such as self-esteem, influence how one is willing to interact with any information; and thus these beliefs influence learning. Fennema and Sherman (1976) made a similar comment, that confidence in oneself is related to what one is willing to attempt, and further that females tend to underestimate their own intellectual abilities more than do boys. According to Schoenfeld (1989), research studies consistently show positive correlations between confidence and achievement. Unfortunately, many students have come to believe that they lack a mathematical mind, and thus they should not be expected to excel in mathematics (Tobias, 1978). Schoenfeld (1985, 1988) noted that many college students believe that they are not capable of creating mathematics, and thus feel they should accept procedures without trying to understand how they work. Schoenfeld (1989) also surveyed grade ten to twelve students and found that students firmly believe in native ability when it comes to mathematics. The belief that the individual either has a mathematical mind or does not seems pervasive, and thus will be examined under the second category of beliefs, namely, "*Beliefs about the Individual as a Learner of Mathematics*".

The Culture of the Mathematics Classroom

The third set of beliefs to be examined will be beliefs about the culture of the mathematics classroom. One aspect of the culture of the classroom is the atmosphere students perceive in the classroom. For example, Sells (1973) interviewed students and found that girls often feel as if teachers belittle their intellectual performance (Fennema and Sherman, 1976). Another common belief about the culture of the mathematics classroom has to do with expectations of the learner. The belief is that the mathematics student is expected to be passive and the teacher to be active in the teaching-learning process

(Spangler, 1992). In other words, students tend to believe that what is expected of them in the mathematics classroom is to sit back, listen, and absorb information, rather than to be actively involved in the learning process. Students' beliefs about the culture of the classroom will also be examined in terms of their comfort level in the classroom, and their sense of whether or not the teacher is interested in them as individuals. Cooper and Robinson (1991) reported positive correlations between students' perceived level of teacher and parental support and students' expectations of their own mathematical efficacy. This third category of beliefs, namely "*Beliefs about the Culture of the Mathematics Classroom*", will thus focus on the culture of the mathematics classroom in terms of the atmosphere of the classroom, perceived expectations of the students, the students' comfort level in the classroom, and the students' perception of the interest in individual students shown by math teachers.

How Mathematics is Best Learned

The final category of beliefs to be studied is that of beliefs about how mathematics is best learned. Buerck (1985) suggests that many women believe mathematics is learned by memorizing symbols and processes which have no meaning to the student. She goes on to suggest that the reasoning process is at the heart of how mathematicians "do" mathematics, but that most mathematics students do not see mathematics that way. This result is not much of a surprise when one considers the fact that mathematics is generally taught under the assumption that the learners *absorb* what has been covered. This conception is known as the *absorption model* (Romberg & Carpenter, 1986). An opposing point of view can be found with the *constructivist model*, suggesting that "Human beings are theory builders; from the beginning we construct explanatory structures that help us find the deeper reality underlying surface chaos" (Carey, 1985, P. 194). According to Spangler (1992), students' learning experiences are likely to contribute to their beliefs

about what it means to learn mathematics. Thus, the fourth category of beliefs to be examined in this study will pertain to "*Beliefs about how Mathematics is Best Learned*".

Journal Writing

The list of supporters of journal writing is long. One of the reasons that teachers and researchers support journal writing is that it is perceived to offer benefits in terms of student understanding. Increased student understanding is conjectured to occur as a direct result of the more personalized learning that takes place through journal writing. Mett (1989) suggests that journal writing is a highly effective means for students to personalize their knowledge. Journal writing is used by Mett to help students explore what they do and do not understand, and to help them apply new concepts to their own experiences. McIntosh (1991) states that the purpose of having students write in journals is for them to reflect on what they are learning and to learn while they are reflecting on what they are learning. McIntosh goes on to say that students' journal writing entries may lack precision due to the fact that students are using their own words. However, she states that this is well made up for by the likelihood that in using their own words, the students will ascribe more meaning to the ideas and are therefore more likely to *understand* them as opposed to *memorize* them. Marting, Medway, Smith and D'Arcy (1973) stress the importance of writing as a thinking skill: "When we try to put things into words, we find out what we think and know, and we come to know in different ways." Enhanced student comprehension is one definite advantage of journal writing that is expounded by teachers who have used journal writing in their classes.

Another potential benefit to be gained from the journal writing process is improved communication between teacher and student. Geeslin (1977) points out that written explanations, as opposed to verbal explanations, are advantageous because the written work is available for further, closer inspection by the teacher, and for later discussion

between teacher and student. According to Schmidt (1985), writing tends to open up the lines of communication between teacher and student and can help to build a sense of community and trust so that students will be more willing to take risks. McIntosh (1991) notes that while half the benefit of journal writing is students' enhanced learning, the other half is teachers' enhanced awareness of students' learning, knowledge of students' thinking, and information as to where students are in need of assistance.

Journal writing can also benefit students by helping them to achieve an increased feeling of self-worth. Graves (1983) says that by encouraging students to write expressively, they are given the implicit message that they have worthwhile ideas. McIntosh (1991) suggests that journal writing may be a way of helping students who have a difficult time in mathematics, but who may excel in literature courses. Journal writing would appeal to their strengths and perhaps make them feel more positive about mathematics, as well as enhance their learning. Journal writing may also help students to acknowledge and deal with any negative feelings they may have towards mathematics, and thereby help them move on "as if relieved of a burden" (Buerck, 1985). "Writing out one's thoughts often brings a deeper clarity and/or a new insight and with these comes a new sense of confidence" (Buerck, 1985).

There is much support of journal writing as an effective learning tool in the classroom. Many potential benefits of incorporating journal writing into the culture of the classroom are indicated. These benefits include increased student understanding, improved communication between teacher and student, and increased feelings of self worth in the student. These perceived benefits are significant in this study because they relate directly to the beliefs that are to be examined for evidence of change. If students experience an increase in understanding as a result of writing in their journals, they may develop a corresponding change in their beliefs about how mathematics is best learned. If students experience improved communication between themselves and the teacher, they may

develop a corresponding change in their beliefs about the culture of the mathematics classroom. If students experience an increased sense of self worth as a result of writing in their journals, they may develop a corresponding change in their beliefs about themselves as learners of mathematics. Finally, as students are exposed to a new and different instructional process such as journal writing, they may come to see mathematics itself in a different light, and thus experience a change in their beliefs about the nature of mathematics.

Summary of the Review of the Literature

Research on affective issues points overwhelmingly to the fact that affect influences students' learning. When affect is divided into the three components of emotions, attitudes, and beliefs, it is apparent that beliefs are the most cognitive in nature of the three, and are also the most firmly entrenched because they take the longest time to form. Studies consistently show that many students have negative beliefs about mathematics, and that these beliefs interfere with their learning of mathematics. If the goals of the NCTM Standards (1989) are to be met, affective issues such as students' beliefs must be taken into account. A number of leading theorists suggest that beliefs are greatly influenced by the culture the student experiences. This being the case, changes in the culture should bring about corresponding changes in students' beliefs. One such change to the culture of the mathematics classroom is the implementation of regular journal writing exercises. Journal writing may be the key to influencing students' beliefs, not only because it is a change to the culture of the classroom, but because it is a change which itself may have direct impact on the beliefs that students hold.

Chapter Three

METHOD AND PROCEDURES

The purpose of the study was to examine whether a change in instructional practices in the mathematics classroom, specifically the implementation of regular journal writing exercises, would cause a corresponding change in students' beliefs about mathematics. A secondary purpose was to examine what types of beliefs would be affected by such a change.

The Subjects

The subjects in this study were students at two high schools in Winnipeg, Manitoba. From the first high school, designated as School I, four different classes were involved. These classes were each taught by a different teacher, and each class was studying a different level of mathematics. Class A was a grade twelve, general level (ie. not university entrance level) mathematics class. Class B was a grade ten, university entrance level class composed of students identified as being weak in mathematics. Class C was a grade twelve, university entrance level class. Finally, class D was a grade 10, general level math class composed of students identified as being "at risk". From the second high school, designated as School II, two classes were involved. These two classes were both taught by the same teacher and were both studying grade ten, university entrance level mathematics. Because of the homogeneity of these two classes, they were grouped together and labelled as class E for purposes of the study.

The teachers who chose to involve their classes in the study did so because of their interest in the study and in journal writing in particular.

Instrumentation

The instrument used to assess students' beliefs was a Likert-type questionnaire which was developed by the researcher. The standard Likert-type questionnaire consists of statements to which the subject must respond on a scale from strongly disagree to strongly agree, often identified by the numbers one through five. This standard style was modified slightly by changing the range so that it went from one to ten, in order to allow for more flexibility in responses, and thus greater sensitivity to changes occurring during the time period of the study.

The questionnaire consisted of four scales, one for each of the four main belief categories being studied. The scales regarding beliefs about the nature of mathematics, the individual student as a learner of mathematics, and how math is best learned each contained nine statements. The scale regarding beliefs about the culture of the mathematics classroom consisted of seven statements. The statements chosen were intended to reflect the conception of beliefs suggested by Mandler's theory in that they are statements characterized by terms such as "is", "are", and "am", and thus involve a higher degree of cognitive involvement and a lower degree of affective involvement than do attitudes and emotions.

The statements used on the questionnaire were compiled by the researcher and were based on similar statements on instruments designed by Fennema and Sherman (1976), Schoenfeld (1989), Kloosterman and Stage (1992), and Schommer (1993). The statements which appear on the questionnaire were chosen from an initial list of 54 statements compiled by the researcher. Six professionals, including four high school mathematics teachers and one university mathematics professor were given a randomly ordered list of the statements and asked to decide under which of the four main belief categories each best fit. The final questionnaire items were selected according to the extent of agreement among the professionals as to the appropriate category for each statement.

Only statements to which there were at least five identical responses from the six respondents were placed into the final questionnaire. This analysis resulted in a final questionnaire of 34 statements.

The scale items appear in order by scale in Appendix E. On the actual questionnaire given to the students, the statements were in random order, as shown in Appendix F.

Instructional Procedure

Before the study began, the teachers involved in the study were all given some recommendations by the researcher on how to implement the journal writing exercises in their classes. The recommendations were based on the researcher's own experience with journal writing as well as on relevant literature. It was recommended to the teachers that they have the students write in their journals as often as possible, perhaps even every day. It was also recommended that teachers not allow students to take the journals home, as this would inevitably lead to situations where students did not have their journals with them when a writing assignment was given. Another suggestion was that the teachers should try to read and respond to the students' journals as often as possible. Finally, it was suggested that teachers allow approximately five minutes of class time for journal writing each time they asked the students' to write in their journals.

In order to have some degree of consistency in the journal writing experiences that students were exposed to, the teachers were each given a list of journal writing topics to be used with their classes (see Appendix D). The list was composed of twenty five varied types of questions to which students would respond in their journals. Teachers were asked to try to use each topic on the list at least once with their classes. Beyond that, teachers were given the freedom to create and use any ideas of their own for journal writing topics.

Procedure

The study itself began in the first week of February of 1995. During this week, students from the classes involved in the study were given the beliefs questionnaire and asked to respond to each statement on the questionnaire by circling a number from one to ten, where one represented "strongly disagree" and ten represented "strongly agree". For consistency in the sample, students were asked to put the last four digits of their phone number on the questionnaire to allow for the matching of the "before" and "after" questionnaires. Following the completion of the questionnaire, teachers were to begin implementing the journal writing exercises in their math classes on a regular basis.

In June of 1995, after five months of regular journal writing, students were asked once again to respond to the questionnaire. This second questionnaire was identical to the first, except for the addition of an open-ended question which was intended to give students the opportunity to more directly express their feelings about the journal writing process. At this time, the teachers were also asked to fill in a survey (Appendix G) to provide information on some details of their individual experiences with the journal writing. As part of this survey, the teachers were asked to indicate which of the 25 journal writing topics they had actually used with their classes by checking the topics on an attached list.

Interpretation of the Data

In interpreting the data from the student questionnaires, it is important to note that only questionnaires for which there was a corresponding "before" and "after", completed by the same student, were used in the statistical analysis. The design of the study necessitated a match between the respondents before and after the implementation of the journal writing exercises for statistical testing purposes.

The data from the student questionnaires were analyzed statistically using a statistical program called SAS. Using SAS, mean responses and standard deviations were calculated for each item on the questionnaires administered both before and after the implementation of the journal writing exercises. The difference in the mean “before” and mean “after” value was then calculated for each item and a paired t-test was performed on this difference. It should be noted that although the exploratory nature of this study allows for multiple t-tests, the possibility of the occurrence of type I errors is thereby increased.

As well as looking at the individual items on the questionnaire, the four separate scales of the questionnaire were also analyzed in a similar manner. To determine a mean value for a whole scale, the mean values of each of the items composing that scale were averaged on both the “before” and “after” questionnaires. Using a paired t-test for each scale, the mean score “before” was then compared with the mean score “after”.

Information from the teacher survey forms was summarized in a descriptive manner and used to provide background information for interpreting the results of the statistical tests. A descriptive summary of the students’ responses to the open-ended question on the “after” questionnaire was also created to provide further background information for interpreting the results.

Chapter Four

ANALYSIS OF THE DATA

The analysis of the data will be organized into six sections. The first section will statistically compare the individual “before” and “after” items on each scale. The second section will examine the scales as a whole comparing “before” and “after” means for each scale statistically. The third section will provide a descriptive summary of the teachers’ survey forms and relate this information to the analysis of the data. The fourth section will descriptively summarize the responses to the open-ended question on the students’ “after” questionnaire. A subsidiary analysis of the data will be examined in the fifth section, and in the final section, an overall summary of the results of the study will be given.

Individual Scale Items

For each item on the four scales, the mean score and standard deviation were calculated for both the “before” and “after” questionnaires, as well as for the difference between these means. It should be noted that in certain cases a student omitted an item on either the “before” or the “after” questionnaire. In these cases, that student’s data was not used in the calculation of the difference in the “before” and “after” means for that particular item. It is also important to note that the wording of certain items on each scale necessitated the scoring of those items in reverse. Tables 1-4 summarize this information.

On the “Nature of Mathematics” scale (Table 1), a value of one represented a view of the nature of mathematics as a discipline which is characterized by creative, active, problem solving as described in the NCTM Standards (1989). A value of ten represented a view of mathematics which corresponds to Perry’s (1970, 1981) dualistic conception of

Table 1

Scale: The Nature of Mathematics - Itemized Results

Item	Time	<u>M</u>	<u>SD</u>	<u>N</u>
1. Mathematics is mostly facts and procedures that have to be memorized.	Before	5.92	2.52	77
	After	6.17	2.23	77
	Difference	0.25	2.87	77
2. Everything important about mathematics is already know by mathematicians.	Before	4.92	2.43	75
	After	4.84	2.71	77
	Difference	-0.09	2.80	75
3. Mathematics is thought provoking.	Before	4.35	2.06	77
	After	4.75	2.19	77
	Difference	0.40	2.32	77
4. Mathematics can be defined as computation.	Before	6.14	1.87	74
	After	6.40	1.62	75
	Difference	0.28	1.94	72
5. Mathematics is a non-creative subject.	Before	4.78	2.64	77
	After	4.71	2.56	77
	Difference	-0.06	2.78	77
6. If a friend and I got different answers to a math problem, one of use would have to be wrong.	Before	5.40	3.01	77
	After	5.13	3.05	77
	Difference	-0.27	3.07	77
7. Mathematics involves the active pursuit of patterns.	Before	4.70	1.79	77
	After	5.11	1.57	76
	Difference	0.42*	1.81	76
8. In mathematics, something is either right or wrong, there is no middle ground.	Before	5.47	2.46	77
	After	5.48	2.70	77
	Difference	0.01	2.81	77
9. Mathematics involves lots of creative thinking.	Before	4.99	2.33	77
	After	4.96	2.23	77
	Difference	-0.03	2.24	77

Note. On this scale, a response of 1 represented a creative, active, problem solving perception of mathematics. A response of 10 represented a rigid, static, rule-bound perception of mathematics. Items 3, 7, and 9 were scored in reverse.

* $p < .05$, for the t-test.

mathematics, in which students see mathematics as rigid, static, and rule-bound.

Accordingly, a decrease in the mean response value would indicate a shift in students' beliefs which brings them more in line with the vision of the Standards. Of the nine items on this scale, only four experienced a change in this direction, while five went the opposite direction. Any changes in the mean scores which did occur were relatively small. The only item with a change large enough to be considered statistically significant was item number 7, "Mathematics involves the active pursuit of patterns", $t(75) = 2.02$, $p < .05$. However, this change was in the direction indicating a decrease in the students' perception of mathematics as involving the active pursuit of patterns. It is likely that the "pursuit of patterns" was not explicitly examined in any of the students' journal writing exercises. In fact, writing itself may have been seen as an activity which is extremely different from activities in which patterns are actively sought. Students are likely not making the connection between understanding mathematical concepts and recognizing patterns.

On the "Individual as a Learner of Mathematics" scale (Table 2), a value of one represented a view of oneself as not having a "mathematical mind" as described by Tobias (1978), and thus not being capable of creating mathematical ideas. A value of ten represented the opposite view, that one has a mathematical mind and is capable of creating mathematical ideas. Accordingly, an increase in mean response values would indicate a shift in students' beliefs that would bring them more in line with the vision of the Standards. Of the nine items on this scale, only four saw an increase in mean response, while five saw a decrease in mean response. Here again, any changes in the mean values were small, and in fact none were statistically significant changes on this scale.

On the "Culture of the Mathematics Classroom" scale (Table 3), a value of one represented a perception of the mathematics classroom as being a cold, uncaring, unfriendly environment. Conversely, a value of ten represented a perception of the

Table 2

Scale: The Individual as a Learner of Mathematics - Itemized Results

Item	Time	<u>M</u>	<u>SD</u>	<u>N</u>
1. I can do hard math problems if I am persistent and don't give up too soon.	Before	6.91	2.60	77
	After	7.25	2.15	77
	Difference	0.34	2.61	77
2. My creative thinking abilities help me in math.	Before	5.49	2.29	77
	After	5.92	2.15	77
	Difference	0.43	2.31	77
3. When I get a poor grade in mathematics, it's because I haven't studied hard enough.	Before	6.33	2.74	77
	After	6.61	2.41	77
	Difference	0.30	2.67	77
4. When I get a good grade in mathematics, it's because I'm good at math.	Before	6.38	2.58	77
	After	5.88	2.32	76
	Difference	-0.47	2.89	76
5. If I get stuck on a difficult math problem, I might as well give up because I will never solve it.	Before	7.77	2.28	77
	After	7.49	2.24	77
	Difference	-0.27	2.48	77
6. I have great difficulty with time-consuming math problems.	Before	5.16	2.56	76
	After	4.91	2.49	77
	Difference	-0.28	2.67	76
7. When I get a poor grade in mathematics, it's because I'm just not good at math.	Before	6.77	2.61	77
	After	6.53	2.65	77
	Difference	-0.23	3.01	77
8. I am not capable of creating mathematical ideas.	Before	6.13	2.36	76
	After	5.94	2.04	77
	Difference	-0.13	2.02	76
9. I can solve time-consuming math problems.	Before	5.69	2.54	77
	After	6.03	2.51	77
	Difference	0.34	2.51	77

Note. On this scale, a response of 1 represented a perception of self as not capable of creating mathematical ideas. A value of 10 represented a perception of self as capable of creating mathematical ideas. Items 5, 6, 7, and 8 were scored in reverse.

Table 3

Scale: The Culture of the Mathematics Classroom - Itemized Results

Item	Time	<u>M</u>	<u>SD</u>	<u>N</u>
1. In math class, students are expected to just sit back, listen, and absorb information.	Before	7.55	2.36	77
	After	7.71	1.98	77
	Difference	0.17	2.75	77
2. I have some degree of personal contact with my math teacher.	Before	5.52	2.48	77
	After	6.36	2.20	77
	Difference	0.84**	2.50	77
3. If I don't understand something in mathematics, I would be able to talk to the teacher about it.	Before	8.42	1.98	77
	After	7.92	2.05	77
	Difference	-0.49*	2.05	77
4. My mathematics teacher is aware of what I understand and do not understand.	Before	5.78	2.18	77
	After	6.14	1.94	77
	Difference	0.36	2.09	77
5. I can communicate with my mathematics teacher.	Before	7.32	2.05	76
	After	7.58	2.08	77
	Difference	0.25	2.27	76
6. Mathematics teachers are interested in teaching math only, they do not care about students as individuals.	Before	7.95	2.21	77
	After	8.03	2.08	76
	Difference	0.11	2.69	76
7. My mathematics teacher gives me help with things I do not understand.	Before	8.16	1.88	77
	After	8.24	1.80	75
	Difference	0.03	1.77	75

Note. On this scale, a response of 1 represented a perception of math class as a cold, uncaring, unfriendly environment. A response of 10 represented a perception of math class as a warm, caring, communicative environment. Items 1 and 6 were scored in reverse.

* $p < .05$. ** $p < .01$, for the t-test.

mathematics classroom as being a warm, caring, communicative environment. As such, an increase in mean response value would indicate a change in students' beliefs which would bring them more in line with the vision of the Standards. On this scale, all but one of the items experienced a change in this direction. Two of the items on this scale experienced a change great enough to be considered statistically significant. Item number 2, "I have some degree of personal contact with my mathematics teacher" showed the greatest degree of change of all the items on all four scales, $t(76) = 2.96$, $p < .01$. This change indicated that students felt they had increased personal contact with their mathematics teachers. This response is consistent with the fact that journal writing provided a new method of contact between the teacher and student which the student had not experienced before the study. On the other hand, item number 3, "If I don't understand something in mathematics, I would be able to talk to the teacher about it", showed a statistically significant change in the opposite direction, $t(76) = -2.11$, $p < .05$. It is possible that students felt less inclination to actually speak to the teacher about a mathematics problem as they became more and more comfortable with communicating in written form through the journals.

On the "How Mathematics is Best Learned" scale (Table 4), a response of one indicated a perception that mathematics is best learned through an active approach which involves activities such as working with ideas, and sharing ideas with others. A response of ten, on the other hand, indicated a perception that mathematics is best learned through a passive approach involving absorption of ideas, and memorization of procedures. Thereby, a change in line with the view of the Standards would be one in which the mean values decreased. Of the nine items on this scale, six underwent a change in this direction, two underwent a change in the opposite direction, and one experienced no change. Of these changes, none were extreme enough to be considered statistically significant.

Table 4

Scale: How Mathematics is Best Learned - Itemized Results

Item	Time	<u>M</u>	<u>SD</u>	<u>N</u>
1. Mathematics is best learned by memorizing rules and procedures.	Before	6.70	2.67	77
	After	6.60	2.11	77
	Difference	-0.10	2.41	77
2. Mathematics is best learned by trying to understand the processes involved.	Before	3.01	1.77	75
	After	3.25	1.69	77
	Difference	0.27	2.27	75
3. Mathematics is best learned by examining lots of different ways to do the same problem.	Before	4.78	2.50	77
	After	4.56	2.11	77
	Difference	-0.22	2.85	77
4. Mathematics is best learned by memorizing the exact procedures that the teacher uses.	Before	5.87	2.72	77
	After	5.49	2.35	76
	Difference	-0.38	2.27	76
5. The best way to learn math is to simply sit back and listen to the math lesson.	Before	3.43	2.57	77
	After	3.84	2.28	77
	Difference	0.42	2.59	77
6. Mathematics is best learned by thinking things through individually.	Before	6.22	2.45	77
	After	5.88	1.95	76
	Difference	-0.37	2.62	76
7. The best way to learn math is to memorize all the formulas.	Before	5.70	2.33	77
	After	5.57	2.22	76
	Difference	-0.14	2.12	76
8. Time used to investigate why a solution to a math problem works is time well spent.	Before	4.30	2.32	77
	After	4.30	2.32	77
	Difference	0.00	2.73	77
9. Mathematics is best learned by discussing ideas with others.	Before	4.14	2.19	77
	After	4.00	1.86	77
	Difference	-0.14	2.43	77

Note. On this scale, a response of 1 represented a belief that math is best learned by working with it and sharing ideas. A response of 10 represented a belief that math is best learned by memorizing exact procedures. On this scale, items 1, 2, 8, and 9 were scored in reverse.

Upon examination of the standard deviations for the mean values it was observed that the standard deviation on the difference in the “before” and “after” means was generally on the same order as the standard deviation on those two means individually. This is explained by the fact that the possible range of values on this difference was twice the possible range on the individual “before” and “after” means, since a student’s response could change by nine units in either the positive or the negative direction on this difference calculation. In fact, in all cases the actual range of values was indeed larger on the difference in the means than on the two means individually. Taking the larger range into account, it becomes apparent that although the standard deviation of the difference in the “before” and “after” means is as large as the standard deviations on these two means themselves, the difference values were in fact less widely spread over their range.

The Scales as a Whole

This section will examine the scales as a whole. A mean value for each scale was calculated by taking the average of the mean values of each individual item on that scale. This was done for both the “before” and the “after” questionnaires. The difference in these “before” and “after” means was then calculated, and a paired t-test was done on this difference. Table 5 summarizes the results for this change in the mean for each scale.

Table 5

Analysis of Difference in Whole Scale Means Before and After
(Full Data Set)

Scale	<u>N</u>	<u>M</u>	<u>SD</u>	<u>t</u>	<u>p</u>
Nature	70	0.07	0.89	0.69	0.50
Individual	74	-0.02	1.19	-0.16	0.87
Classroom	73	0.20	1.33	1.31	0.19
Learning	72	-0.05	1.11	-0.41	0.68

As table 5 indicates, none of the scales taken as a whole show any statistically significant changes, since none of the t scores indicated $p < 0.05$. The only trend which is of note is that the change in the mean value for the "Culture of the Classroom" scale was significantly larger than the changes in the mean values on the other three scales.

Teacher Survey Information

This section will provide a descriptive summary of the information received from the teachers involved in the study by way of a teacher survey which they were asked to complete at the end of the study. As part of the survey teachers were asked to indicate, on a list of the journal writing topics, those topics which they had actually used with their classes. A tally of these results is given in Figure 1.

Teachers A through D were all from School I. School I is in a middle class suburb of Winnipeg, but the area immediately surrounding the school is characterized by high rise apartments and low income housing. The cross section of students in the school characterizes the school as equivalent to an inner city, or "core area" school. Attendance is a problem in this school, especially among students in general level courses. This is evident from the low ratio of students who completed both the "before" and "after" questionnaires compared to the total number of students enrolled in the courses. Another reason for this low ratio is that the "after" questionnaire was written by students during their last week of classes before exams. During this time of the year numerous year-end extra curricular activities take students out of their classes. Many students also opt to stay home and study during this week because generally no new material is covered at this time.

Teacher A

Teacher A had a grade twelve, general level (ie. not university entrance level) mathematics class. The class initially had 37 students in it, but only 27 remained by the

Figure 1

Journal Writing Topics Used by Teachers

Topic	Teacher					Tally
	A	B	C	D	E	
Scale: The Nature of Mathematics						
1. Where do the rules in math come from?					x	1
2. What is math? Brainstorm as many ideas as you can come up with.				x	x	2
3. What subject is math the most like and why? What subject is math the least like and why?		x		x		2
Scale: The Individual as a Learner of Mathematics						
1. What is the most difficult math concept to learn so far?		x	x	x		3
2. (After a weekend). How did you use math this weekend?		x		x		2
3. (After completing a test). How do you think you did? If you could study for the test again, what would you do differently?	x	x	x	x	x	5
4. Describe your most positive or most negative experience with math.		x		x	x	3
5. Describe your strengths and weaknesses as a math student.		x		x	x	3
6. What are your goals in math? How do you plan to achieve these goals?	x	x	x		x	4
7. Describe how the concept you learned today will be useful to you in the future.				x	x	2
Scale: The Culture of the Mathematics Classroom						
1. What do you think is the purpose of writing in a math journal?	x		x	x		3
2. How do you feel math class is going so far?	x		x	x		3
3. Describe your favourite math class.	x		x	x		3
Scale: How Mathematics is Best Learned						
1. Write a letter to a younger student explaining today's lesson so he or she will understand it.				x	x	2
2. How does the concept from today's class relate to the other ones you have previously learned?		x			x	2
3. If you had to teach this concept, what would you do to help students understand it?	x			x	x	3

Figure 1 - continued

Topic	Teacher					Tally
	A	B	C	D	E	
4. Your friend was absent from today's class. Summarize today's lesson so that he or she will understand what you learned.			x	x	x	3
5. Choose the easiest and the most difficult question from the last assignment. How are they different? What makes one more difficult than the other?		x				1
6. Create a problem for an upcoming test and solve it. Why do you think it would make a good test question?	x	x		x		3
7. List as many of the different concepts from this unit as you can without looking in your notes.		x			x	2
8. (Given a mistaken solution to a problem). Explain to the person who solved this problem what they did wrong and how they can prevent making this same mistake in the future.			x	x	x	3
9. (Given a term from a recent lesson). Define this term in your own words.		x	x	x	x	4
10. Create a word problem based on today's lesson and solve it.	x					1
11. (Given a typical assignment question). Write in words how you would go about solving this problem.		x	x	x	x	4
12. (After a test). Explain how to correctly solve a problem that you made a mistake on when writing the math test.				x		1

end of the term. Only 8 students completed both the before and after surveys, due mainly to the very irregular attendance of the students.

Teacher A found it very difficult to institute regular journal writing in his class, citing reasons such as: many students did not take the project seriously; many were not inclined to write much, especially since the class was first period in the morning; and attendance and tardiness problems.

Teacher A had his students write in their journals only five or six times during the five month period of the study. Considering the extreme attendance and tardiness problems he experienced with this class, it is likely that any individual student may have only written two or three journal entries in total. Since the purpose of this study was to examine students beliefs before and after five months of regular journal writing, whether or not this class should be included in the final analysis is questionable.

Teacher A used two journal writing topics from the "Individual as a Learner of Mathematics" list, and three topics from the "How Mathematics is Best Learned" list. He responded to the journals twice in total, and did not assign marks for the journals.

Teacher B

Teacher B had a grade ten, university entrance level class composed of students identified as being weak in mathematics. These students attended two math periods per day, rather than one, in an effort to help them master the mathematics material. This extra daily math period occurred only during the first term. During the second term, when the study was conducted, the students attended the standard one class per day. There were 22 students in this class, 11 of whom completed both the before and after survey.

Teacher B managed to have his students write in their journals once a week, on average. He usually responded to the students' journal entries after each entry. Marks were not assigned for the journals.

Teacher B used one journal writing topic from the "Nature of Mathematics" list, six from the "Individual as a Learner of Mathematics" list, all three from the "Culture of the Mathematics Classroom" list, and six from the "How Mathematics is Best Learned" list. He also used some of his own ideas for journal topics, usually not math related, but on a more personal level, such as: "What did you do on the weekend?" or "What are your plans for the future?"

In terms of negative aspects of the experience, teacher B indicated that some students “bucked” and constantly questioned the idea of writing. Teacher B also found that reading and responding to the journals, which took him between 5 and 15 minutes each time the students wrote, added to his workload. He also noted that it was sometimes difficult reading because some students tended to use poorly constructed sentences or give shallow answers.

On the positive side, teacher B found that he got to know his students a little bit better, and that it gave the quiet students an opportunity to communicate with him. He also found that the writing exercises gave him some insight on some of the problem areas that students were experiencing with the course content.

Teacher C

Teacher C had a class of 24 grade twelve, university entrance level students. Fifteen students responded to both the “before” and “after” surveys.

Teacher C had students write in their journals once or twice a week, on average. She responded to the students’ journal entries every time they wrote, and felt that this usually took about 15 minutes. She did not assign any marks for the journal.

Teacher C did not use any topics from the “Nature of Mathematics” list. She used three topics from the “Individual as a Learner of Mathematics” list, none from the “Culture of the Mathematics Classroom” list, and four from the “How Mathematics is Best Learned” list. She also used numerous questions of her own. Some of these questions were related to course content, such as, “What are conics?” and “What is factoring?” Others were of a more personal nature, such as, “How was your spring break?”

The negative aspects of the experience for teacher C included the extra marking, although she indicated that this was “not that big a deal”; dealing with a few students who thought the journals were a waste of time; and time constraints. The positive aspects of the

experience for teacher C included the change of pace from the regular classroom activities, being able to deal with “feelings”, and having better communication with her students.

Teacher D

Teacher D had a class of 20 grade ten, general level mathematics students. These students were categorized as “at risk” and were grouped together in other classes as well. They also had one teacher for both science and mathematics, and another for both English and social studies, in an effort to better respond to their special needs. Six of the students responded to both the “before” and “after” surveys.

Teacher D had his students write in their journals two or three times per week, and responded to their journal entries each time they wrote. He found that it took approximately fifteen minutes to respond to the journal entries each time. Marks were assigned for the journal entries, and the teacher indicated that the marks were based mainly on effort and impression. The journal mark constituted 10% of the students’ term two grade.

Teacher D used two topics from the “Nature of Mathematics” list, six from the “Individual as a Learner of Mathematics” list, all three from the “Culture of the Mathematics Classroom” list, and eight from the “How Mathematics is Best Learned” list. Some of this teacher’s own ideas for journal entries included, “How do you feel prior to writing a test or exam?” and, “How do you cope with those feelings?”

Teacher D did not cite any negative aspects of the experience. In terms of positive aspects, he felt that it gave him a clearer insight into his students, gave him another opportunity to have one on one communication with the students, and gave students an opportunity to provide questions for tests and quizzes. His overall comment about the experience was that it was a terrific exercise that he has added to his teaching “bag of tricks”.

Teacher E

Teacher E was the only teacher from School II. School II is situated in a middle class suburban area of Winnipeg. Attendance is not as much of a problem in this school. This is evident from the higher ratio of students who were present for both the before and after surveys.

Teacher E involved two of her classes in the journal writing exercises. Both classes were grade ten, university entrance level classes, each with 26 students. Because of the homogenous nature of these two classes, they were grouped together as one class for purposes of this study. Of the 52 students making up class E, 37 responded to both the before and after surveys.

Teacher E had her students write in their journals once or twice a week, and she read and responded to the journals each time the students wrote. She indicated that it took approximately 30 minutes per class to mark the journals. Ten marks were assigned for effort on the journal entries.

Teacher E did not use any of her own questions for the journal topics. She used two of the "Nature of Mathematics" topics, five of the "Individual as a Learner of Mathematics" topics, all three of the "Culture of the Mathematics Classroom" topics, and eight of the "How Mathematics is Best Learned" topics.

The only negative aspect of the experience that teacher E mentioned was the added work that it meant for her. The positive aspects of the experience included getting to know the students better; finding that students were gaining confidence, which transferred to them asking more questions in class; and learning where some of the students' errors in thinking were coming from.

Based on the information given by teachers in the teacher survey form, it would appear that to varying degrees, all the teachers involved in the study except for teacher A

were able to implement the journal writing as intended at the outset of the study. Because of the difficulties in implementing regular journal writing exercises experienced by teacher A, a Subsidiary Analysis section has been added to examine the results as they would appear if the students from class A were omitted from the study.

Open Ended Question for Students

On the “after” survey, students were asked to respond to an open-ended question. The question was “What are your overall feelings about journal writing in math class?” The students’ responses to the open ended question are given in Figure 2. They are grouped by class because the nature of the responses to the question seemed to be somewhat indicative of the nature of the class from which the students came. Only questionnaires for which there was a corresponding “before” and “after” were examined here as these were the only ones for which the researcher could be certain that the students had actually been enrolled in the class for the full five months of the study. Judging students’ responses as either positive, negative, or neutral, it was determined that 71% of the responses were positive, 11% were negative, and 18% were neutral in nature. This indicates that for the most part, students are accepting of the practice of journal writing, and in fact, in many cases have very positive things to say about it.

It is interesting to note that responses were generally more positive in the higher level classes, both in terms of grade level and course level. It is possible that students with greater cognitive processing capabilities find journal writing to be both easier to handle and of more benefit to them as learners. Putting one’s thoughts into words requires a great deal of cognitive effort, and may thus be very frustrating to students operating from a lower cognitive processing level.

Student Responses to Open Ended Question

Class A - Grade Twelve, General Level

I thought it was a pretty good idea because it helped me to understand what exactly about a unit I wasn't understanding.

I do not mind journal writing in math class because it is a change from doing math questions all the time.

We didn't write in it often enough to know if it helped. Maybe if the teacher or students was committed then maybe the outcome would've been better. I think it's a great idea to have journals in Math. People get to know themselves better when it comes to Math and the teacher can understand the problems the student is having in Math and help the student in that department.

We only did it once or twice, but it was okay.

I didn't think it made any difference at all.

We didn't write very often, so I don't think it really helped. But it seems like it could be a good idea.

Okay!

Class B- Grade Ten, University Entrance Level, Identified Weak Students

It was okay. I didn't mind doing it. It was better than Math right away.

It helped me in some situations but it wasn't that great.

Don't really care.

Well it was kind of different to be writing in journals but it gave us a break from math. I kind of liked it because I love to write.

I think by writing Journal in Math class it can help you in different ways. Journals can help you in the future.

It is good but we should do better #'s & either do it 1 a week or on a normal schedual.

It's O.K. but if I didn't have to, I wouldn't.

I think some of the things we wrote helped me do a little better in math because it helped me to remember some procedures cause we had to write them out.

Figure 2 - continued

I thought it kind of got of topic alot and I thought it was pretty boring. I'm not too sure if it did help me with math or not.

Class C- Grade Twelve, University Entrance Level

It was kind of different I guess I partly put my goals down on paper and it was better than just saying them.

I think that journal writing is a good idea in math class. It gives us as students a chance to express ourselves and the teacher also gets an idea about what his/her student is like.

It's O.K., its a nice break in the day. I'm not sure if it changed or helped anything though.

I felt that journal writing in mathematics was very unusual. I helped me understand things about math that I didn't really get. Overall it was a very interesting time.

I did not get a chance to participate enough in the journal writing to realize its potential; but I'm sure that if used in the right context, it could be a very effective learning tool.

I thought it was a good idea. Just to kind of do something a little different in math class.

I think it is a good idea because it gives you a chance to think about different problems in a different format. It helps you understand math because you can see where you went wrong in understanding something.

Didn't like, found it to be a waste of class time.

This was a good thing to help me the student communicate with my teacher on topic I'm having trouble with!

Writing in a journal in math class helped me understand problems more because I could write them in my own words and understand them more clearly. It also helped me to get a 1 on 1 relationship with my math teacher.

I liked it! It was a good break from the humdrum of the traditional math class.

It wasn't bad. It was kind of fun sometimes.

It helped, to communicate with [teacher C] alot more, because this way, she wasn't always helping somebody else too.

Journal writing was a nice change and is also a way to communicate better with the teacher.

Well it is good because makes you think if you know something of or about math, and also it is good because is the only way how our teacher can see how and what are our thinkins and feelings.

Class D - Grade Ten, General Level, "At Risk" Students

I thought it was a good idea. I gave us the chance to know our teacher and ask any questions we might have about anything.

I don't like it. It sock.

I actually like journal writing it helps me communicate with the teacher more better and I can write what I like and do not like in our math class and I don't mind continuing it.

It was alright we got to right about Math

I never got anything out of it.

Its a waist

I did not really like journal writing it was a waste of my time (no offense) I have alot of catching up to do and journal writing was not one of them.

Class E - Grade Ten, University Entrance Level

It's cool.

I think the Journal was good because it gave me a chance to ask question. It also gave me a student to teacher relationship. Which I feel is very important in doing good in math.

It's good for the teacher but that's all.

I liked the journals.

The journal writing at times is interesting, but at other times boring. There need's to be more in-depth questions.

I liked how the teacher could find out how the class felt.

The Journal was easy and good to write in.

I liked getting the comments back from the teacher on what I wrote. I thought journal writing was O.K.

It helped me to say things to my teacher personally eg. Any problems I had with the way she taught.

Figure 2 - continued

I think it was good except the questions could be different.

I think it is a good idea to have journal writing in math calss because it helps students and teachers to communicate better.

I feel it is a good way to communicate with your teacher.

My overall feelings about Journal writting in math class are it's good because you can ask questions your scared to ask in class and the teacher can get to know you on a one on one basis. I like Journal writing.

Hate it.

I think journal writing was a good thing, it helped me understand my math questions a lot better. I can now do the problems, say how to solve it, and write out how to do it in words. It was a great help! Thanx!

Not too bad.

It was good because we could communicate better.

It's okay, it's good because if you can't communicate with your math teacher personally, at least you can write to the teacher instead.

It got me away from the actual calculating and mind blowing problems. It helped me get through to the teacher that I hate math. Now she knows and it's great to get it off my chest.

I did not mind.

They are okay but are a little time consuming.

It was not bad.

It wasn't bad. You got to know the teacher better.

I didn't really enjoy writing in my journal. But I liked when [teacher E] would write something back. I just thought it was a good way to waste class.

good to see if you're doing something right, and if not, you get help.

I like it becuae it gives me a chance to express my ideas about the subject of math.

Figure 2 - continued

Productive way to waste class time.

I felt that it allowed us as students to communicate on a more open level with the math teacher, not only educational, but personal as well. It also helped to understand problems more into depth. I believe it was a good ideas and it helped me in more than one way.

Journal writing was O.K. because it gave me a chance to say what I think about what we were doing in math.

Journal writing was weird, so I don't think I want to do it again.

I think writing a response journal in math is a good exercise which helps the teacher understand the students work habbits, etc.

I thought it was good because [teacher E] then knew where I was having problems in the coarse.

Journal writings are alright but we could do with out them.

It was possible to categorize a large number of the positive responses to the open-ended question into three different areas. These areas were 1) appreciation of the change in routine, 2) feelings of increased understanding of subject matter, and 3) appreciation of the increased communication between teacher and student. From the 51 positive responses to the open-ended question, the researcher found 8 references to appreciation of the change in routine, 12 references to feelings of increased understanding of subject matter, and 23 references to appreciation of the increased communication between teacher and student.

The numerous references to increased communication between teacher and student combined with the statistically significant change observed on the scale item, "I have some degree of personal contact with my mathematics teacher" seem to indicate that the journal writing had the greatest effect on students' beliefs about the culture of the mathematics classroom.

Subsidiary Analysis of the Data

As earlier noted, teacher A had a great deal of difficulty in regularly implementing journal writing exercises in his mathematics class. As a result, the students in this class did not receive the regular exposure to journal writing that was anticipated and called for at the outset of the study. For this reason, it is worth examining the data set for the whole scale analysis with class A removed. The statistical calculations were done in the same way as for the whole scale analysis which used the entire data set. Again, a mean value for each scale was calculated by taking the average of the mean values of each individual item on that scale. This was done for both the "before" and the "after" questionnaires. The difference in these "before" and "after" means was then calculated, and a paired t-test was done on this difference. Table 6 summarizes the results for this change in the mean for each scale.

Table 6

Analysis of Difference in Whole Scale Means Before and After
(Data Excluding Class A)

Scale	<u>n</u>	<u>M</u>	<u>SD</u>	<u>t</u>	<u>p</u>
Nature	63	0.04	0.89	0.35	0.73
Individual	67	-0.02	1.22	-0.16	0.88
Classroom	65	0.34	1.31	2.09*	0.04
Learning	64	-0.07	1.11	-0.50	0.62

* $p < 0.05$

As Table 6 shows, there is statistical significance on the "Culture of the Classroom" scale, $t(64) = 2.09$, $p < .05$. when class A is removed from the data set. This lends further evidence to the fact that students' beliefs about the culture of the mathematics

classroom *are* affected by the implementation of *regular* journal writing exercises in mathematics class. None of the other scales indicated any statistically significant changes in students' beliefs.

Summary of the Analysis of the Data

This section began by looking at changes in the mean scores on the beliefs questionnaire of each individual item on the questionnaire. It was seen that one particular item on the "Culture of the Mathematics Classroom" scale experienced a substantial change compared to all the other items on the questionnaire. The scales as a whole were then examined for changes in their mean values, and while no changes were considered statistically significant, the scale which experienced the greatest overall change was the "Culture of the Mathematics Classroom" scale. In looking at the data from the teachers involved in the study, it became apparent that one of the classes involved in the study had not satisfactorily met the conditions outlined at the beginning of the study, suggesting that a subsidiary analysis of the data would be relevant. The subsidiary analysis did in fact indicate a much stronger change in the "Culture of the Mathematics Classroom" scale when this class was eliminated from the data set. The change reached the $p < .05$ level of significance on the t-test. Examination of students' responses to the open ended question on the final questionnaire also indicated that students perceived a change in the culture of the mathematics classroom in terms of increased communication with the teacher.

Putting all of this information together, it becomes evident that of the four belief categories examined in this study, one was impacted by the implementation of regular journal writing exercises. The belief category that was affected was that of students' beliefs about the culture of the mathematics classroom.

Chapter Five

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

Summary of the Study

Questions and Procedures

The purpose of this study was to examine the effect of journal writing on students' beliefs about mathematics. Two questions were posed for the investigation:

1. Will the implementation of regular journal writing exercises in the mathematics classroom have any effect on students' beliefs about mathematics?
2. What types of beliefs will be affected by such a change?

In order to answer these questions, a Likert-type questionnaire was developed to be given to five classes of mathematics students at two different times. The first time students responded to the questionnaire was before they began regular journal writing in their mathematics classes. The second time was after the students had been exposed to five months of regular journal writing exercises.

Results

Analysis of the data produced from the "before" and "after" questionnaires was examined on an item by item basis, as well as on a whole scale basis. On the item by item analysis, one particular item stood out as having experienced the most significant amount of change. This item, from the "Culture of the Classroom" scale, was "I have some degree of personal contact with my mathematics teacher." On the whole scale analysis it was observed that, using the entire data set, the greatest amount of change occurred in the "Culture of the Classroom" scale, although this change was not large enough to be considered statistically significant. However, when the same analysis was done on the data

set after removing the class which had not satisfactorily implemented the regular journal writing, the results did indicate a statistically significant change on this scale. Student responses to an open-ended question about the journal writing experience were also examined, and the greatest impact on students seemed to be in their appreciation of the increased communication between themselves and the teacher. This lends even more support to the results which indicate that students' beliefs about the culture of the mathematics classroom were changed to a significant extent. The students in this study seem to have developed a belief more in line with the views of the NCTM Standards (1989), in that they see the mathematics classroom as a more open and hospitable environment in which communication takes place.

Implications of the Results

The results of this study indicate that it may be possible to define a new view of the mathematics classroom in which students beliefs about mathematics actually enhance their learning rather than act as a hindrance to it. Such a classroom is envisioned by the Standards, but it will have to be enacted by the teachers. If teachers come to see that effective changes in their instructional practices can produce positive changes in students' beliefs, they may be receptive to adjusting their instructional practices so that they will be more in line with those outlined in the Standards.

The results of this study indicate the possibility of changing students' beliefs about the culture of the mathematics classroom. However, it is important not to overlook the fact that this belief was the only one out of the four beliefs examined that was changed to any measurably significant degree. The implementation of journal writing had little, if any, impact on the other three beliefs. This may be partially due to the fact that the study took place over the course of only five months, and that beliefs tend to be firmly rooted and thus difficult to change over short periods of time. It may also be due to the fact that the

students needed more than five months exposure to the journal writing itself in order to more completely accept it as part of mathematics class. It is also possible that journal writing is not the instructional change which is required to impact on these other beliefs.

Recommendations for Further Research

This study was done from an exploratory perspective. The questionnaire used in this study was designed with the intent of forming an overall picture about students' beliefs on the four belief scales. It was not designed in such a way that every item on a particular scale would represent either a positive or negative statement about the exact same belief. Rather the scale items were chosen to represent a variety of possible beliefs that a student could hold in each belief category. This was most evident in the "Culture of the Mathematics Classroom" scale, where items such as "I can communicate with my mathematics teacher," and "In math class, students are expected to just sit back, listen, and absorb information," could not be considered as identifying the exact same belief. Rather, they indicate two different beliefs that a student could hold under the broader category of the culture of the mathematics classroom. With this knowledge in mind, it would be of benefit to subsequent researchers in this area to design scales that are intended to more clearly polarize students' beliefs, in order that a more accurate analysis be possible.

In this study it was found that one particular set of beliefs, namely beliefs about the culture of the mathematics classroom, may be impacted by changing instructional practices in the mathematics classroom. What remains to be seen is how numerous other beliefs that students hold can be affected in a positive way that will enhance their experience with and learning of mathematics. Other instructional practices in line with the vision of the Standards could be examined in an effort to determine what effect they might have on students' beliefs. One such study, by Hatfield (1991) examined the effect of exposing

junior and senior high students to problem-solving software. The results did not indicate any change in students' beliefs about mathematics.

Respected educational researchers such as Schoenfeld (1983), Silver (1985), and Kloosterman and Stage (1992) assert that beliefs play an integral role in students' ability to learn mathematics. Accepting this premise, factors which affect students' formation of beliefs must continue to be studied until the educational community can satisfactorily claim that its students hold beliefs which foster interest in and promote the learning of mathematics.

Conclusions

In this study, no measurably significant change was found in students' beliefs about the nature of mathematics, the individual as a learner of mathematics, or how mathematics is best learned, following five months of regular exposure to journal writing in mathematics class. However, a statistically significant change did occur in students' beliefs about the culture of the mathematics classroom. Whether this change in students' beliefs can be directly attributed to the change in instructional practices is unclear. What is also unclear is how other types of beliefs which students hold about mathematics can be affected in a way that gives students more power as mathematical problem solvers in our increasingly technological society.

If the reform of mathematics education suggested by the Standards (1989) is to take hold, teachers must be exposed to research of this type; research which indicates that the newly recommended instructional practices do in fact work, and may in fact have a positive impact on students' beliefs. They need to see that change is possible, and that this change can and will lead to better understanding of mathematics by students.

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Appendix A

Letters to Principals and School Divisions

November 16, 1994

Dear Mr. Ruff:

I request your permission to conduct a survey of a number of mathematics students at Dakota Collegiate. The information from the survey will be used in my Master's of Education thesis. The purpose of the thesis is to examine the effects of journal writing in math class on students' beliefs about the nature of mathematics and about themselves as learners of mathematics.

The journal writing exercises will range from writing about mathematics content, processes, and terminology, to writing about how the student feels math class is going, how well the student is understanding the math content, and how the student feels towards mathematics in general. Much current literature indicates that writing exercises such as these are beneficial to students in that they offer students an opportunity to review and reflect on their own thinking, and to clarify their thinking processes by putting them into words. They also provide the teacher with a method other than the standard test to examine the extent of understanding that each student individually has achieved.

The students will be involved in journal writing exercises in math class during the new year, and the survey will be given to them once before the writing exercises, once during, and once following. The survey will ask students to indicate their level of agreement with a number of belief statements about the nature of mathematics, and about themselves as learners of mathematics. Students will be asked *not* to put their names on the survey, in order that the responses be confidential. Results of the survey will be used only for purposes of this study. The class time involved for completing the surveys will be approximately ten minutes. An informational letter will be sent home to parents before the study begins, and students will have the option of not participating in the survey if they so choose.

Please sign below to indicate your consent. Thank you.

Sincerely,

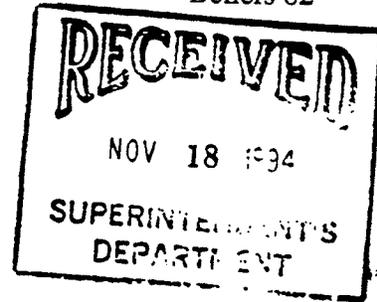
Pamela Holens

.....
I give my consent to Pamela Holens to conduct the above outlined survey for purposes of her Master's of Education thesis.

signature: _____

date: _____

Nov/16/94



November 16, 1994

Dear Mr. Sparkes:

I request your permission to conduct a survey of a number of mathematics students at Dakota Collegiate. The information from the survey will be used in my Master's of Education thesis. The purpose of the thesis is to examine the effects of journal writing in math class on students' beliefs about the nature of mathematics and about themselves as learners of mathematics.

The journal writing exercises will range from writing about mathematics content, processes, and terminology, to writing about how the student feels math class is going, how well the student is understanding the math content, and how the student feels towards mathematics in general. Much current literature indicates that writing exercises such as these are beneficial to students in that they offer students an opportunity to review and reflect on their own thinking, and to clarify their thinking processes by putting them into words. They also provide the teacher with a method other than the standard test to examine the extent of understanding that each student individually has achieved.

The students will be involved in journal writing exercises in math class during the new year, and the survey will be given to them once before the writing exercises, once during, and once following. The survey will ask students to indicate their level of agreement with a number of belief statements about the nature of mathematics, and about themselves as learners of mathematics. Students will be asked *not* to put their names on the survey, in order that the responses be confidential. Results of the survey will be used only for purposes of this study. The class time involved for completing the surveys will be approximately ten minutes. An informational letter will be sent home to parents before the study begins, and students will have the option of not participating in the survey if they so choose.

Please sign below to indicate your consent. Thank you.

Sincerely,

Pamela Holens

I give my consent to Pamela Holens to conduct the above outlined survey for purposes of her Master's of Education thesis.

signature: _____ date: Nov 21/94

RECEIVED
RIVER EAST SCHOOL DIV. 9
SUPERINTENDENT'S DEPT.

FEB 1 1995

February 1, 1995

Per _____
A.M. _____ P.M. _____

Dear Mr. Wall:

One of the math teachers at River East Collegiate, _____, has agreed to participate in a study related to a thesis I am doing towards a Master of Education degree at the University of Manitoba. The purpose of the thesis is to examine the effects of journal writing in math class on students' beliefs about the nature of mathematics and about themselves as learners of mathematics.

_____ has agreed to spend a few minutes each class getting her math students to write math related journal entries. The journal writing exercises will range from writing about mathematics content, processes, and terminology, to writing about how the student feels math class is going, how well the student is understanding the math content, and how the student feels towards mathematics in general. Much current literature indicates that writing exercises such as these are beneficial to students in that they offer students an opportunity to review and reflect on their own thinking, and to clarify their thinking processes by putting them into words. They also provide the teacher with a method other than the standard test to examine the extent of understanding that each student individually has achieved.

The survey will be given to the students once before the writing exercises and once following. The survey will ask students to indicate their level of agreement with a number of belief statements about the nature of mathematics, and about themselves as learners of mathematics. Students will be asked *not* to put their names on the survey, in order that the responses be confidential. Results of the survey will be used only for purposes of this study. The class time involved for completing the surveys will be approximately ten minutes. An informational letter will be sent home to parents before the study begins, and students will have the option of not participating in the survey if they so choose. Please contact me at Dakota Collegiate (256-4366) or my advisor, Dr. Lars Jansson at the U of M (474-9039) if you have any questions.

Please sign below to indicate your consent. Thank you.

Sincerely,


Pamela Holens

I give my consent to Pamela Holens to conduct the above outlined survey for purposes of her Master's of Education thesis.

signature: _____
Mr. G. Wall, Superintendent
River East School Division

date: Feb. 3, 1995.

February 1, 1995

Dear Dr. Welsh:

One of the math teachers at River East Collegiate, _____, has agreed to participate in a study related to a thesis I am doing towards a Master of Education degree at the University of Manitoba. The purpose of the thesis is to examine the effects of journal writing in math class on students' beliefs about the nature of mathematics and about themselves as learners of mathematics.

_____ has agreed to spend a few minutes each class getting her math students to write math related journal entries. The journal writing exercises will range from writing about mathematics content, processes, and terminology, to writing about how the student feels math class is going, how well the student is understanding the math content, and how the student feels towards mathematics in general. Much current literature indicates that writing exercises such as these are beneficial to students in that they offer students an opportunity to review and reflect on their own thinking, and to clarify their thinking processes by putting them into words. They also provide the teacher with a method other than the standard test to examine the extent of understanding that each student individually has achieved.

The survey will be given to the students once before the writing exercises and once following. The survey will ask students to indicate their level of agreement with a number of belief statements about the nature of mathematics, and about themselves as learners of mathematics. Students will be asked *not* to put their names on the survey, in order that the responses be confidential. Results of the survey will be used only for purposes of this study. The class time involved for completing the surveys will be approximately ten minutes. An informational letter will be sent home to parents before the study begins, and students will have the option of not participating in the survey if they so choose. Please contact me at Dakota Collegiate (256-4366) or my advisor, Dr. Lars Jansson at the U of M (474-9039) if you have any questions.

Please sign below to indicate your consent. Thank you.

Sincerely,


Pamela Holens

.....
I give my consent to Pamela Holens to conduct the above outlined survey for purposes of her Master's of Education thesis.

signature: _____

date: _____

Dr. W. Welsh, Principal
River East Collegiate

Appendix B

Letter from Principal

RIVER EAST SCHOOL DIVISION NO.9

River East Collegiate



295 Sutton Avenue, Winnipeg, Manitoba R2G 0T1 Telephone 338-4611 • Fax 338-9515

W. WELSH, Ed. D. Principal
G. PANKIEWICZ, Ph. D. Vice-Principal
H. E. SCHROEDER, B.A., B.Ed. Vice-Principal
01 February 1985

Mr. G. Wall
Superintendent
RIVER EAST SCHOOL DIVISION NO. 9

Dear Mr. Wall:

I received the accompanying fax today.
maintain a journal - the idea has merit.

told me about having her math students

The proposed survey does not appear to be a problem and I support allowing the survey to take place.

Please let me know if you have any concerns.

Yours truly,

W. Welsh
Principal

/dp

Appendix C

Letter to Parents

February 3, 1995

Dear Parents/Guardians:

This is an informational letter regarding a survey that your son or daughter will be asked to complete in his or her math class. I am currently working on my Master of Education degree at the University of Manitoba, and the information from the survey will be used as part of my thesis. The purpose of the thesis is to examine the effects of journal writing in math class on students' beliefs about the nature of mathematics and about themselves as learners of mathematics.

The journal writing exercises will range from writing about mathematics content, processes, and terminology, to writing about how the student feels math class is going, how well the student is understanding the math content, and how the student feels towards mathematics in general. Much current literature indicates that writing exercises such as these are beneficial to students in that they offer students an opportunity to review and reflect on their own thinking, and to clarify their thinking processes by putting them into words. They also provide the teacher with a method other than the standard test to examine the extent of understanding that each student individually has achieved.

The students will be involved in journal writing exercises in math class for the remainder of the school year, and the survey will be given to them once before they begin the writing exercises, and once near the end of the school term. The survey will ask students to indicate their level of agreement with a number of belief statements about the nature of mathematics, and about themselves as learners of mathematics. Students will be asked *not* to put their names on the survey, in order that the responses be confidential. Results of the survey will be used *only* for purposes of this study. The class time involved for completing each of the surveys will be approximately ten minutes. Students will be permitted to withdraw from the study at any time without penalty of any sort. If you have any concerns or would like any additional information about the study, please contact me at Dakota Collegiate (256-4366) or my advisor, Dr. Lars Jansson at the University of Manitoba (474-9039). A summary of the results of the study will be available in June upon request.

Sincerely,

Pamela Holens
Mathematics teacher
Dakota Collegiate

Appendix D

Journal Writing Topics Given to Teachers

JOURNAL WRITING TOPICS

Topic: The Nature of Mathematics

- 1) Where do the rules in math come from?
- 2) What is math? Brainstorm as many ideas as you can come up with.
- 3) What subject is math the most like and why? What subject is math the least like and why?

Topic: The Individual as a Learner of Mathematics

- 4) What is the most difficult math concept to learn so far? What is the easiest?
- 5) (After a weekend.) How did you use math this weekend?
- 6) (After completing a test.) How do you think you did? If you could study for the test again, what would you do differently?
- 7) Describe your most positive or most negative experience with math.
- 8) Describe your strengths and weaknesses as a math student.
- 9) What are your goals in math? How do you plan to achieve these goals?
- 10) Describe how the concept you learned today will be useful to you in the future.

Topic: The Culture of the Mathematics Classroom

- 11) What do you think is the purpose of writing in a math journal?
- 12) How do you feel math class is going so far?
- 13) Describe your favourite math class.

Topic: How Mathematics is Best Learned

- 14) Write a letter to a younger student explaining today's lesson so he or she will understand it.
- 15) How does the concept from today's class relate to the other ones you have previously learned?
- 16) If you had to teach this concept, what would you do to help students understand it?
- 17) Your friend was absent from today's class. Summarize today's lesson so that he or she will understand what you learned.
- 18) Choose the easiest and the most difficult question from the last assignment. How are they different? What makes one more difficult than the other?
- 19) Create a problem for an upcoming test and solve it. Why do you think it would make a good test question?
- 20) List as many of the different concepts from this unit as you can without looking in your notes.

- 21) (Given a mistaken solution to a problem.) Explain to the person who solved this problem what they did wrong and how they can prevent making this same mistake in the future.
- 22) (Given a term from a recent lesson.) Define this term in your own words.
- 23) Create a word problem based on today's lesson and solve it.
- 24) (Given a typical assignment question.) Write in words how you would go about solving this problem.
- 25) (After a test) Explain how to correctly solve a problem that you made a mistake on when writing the math test.

Appendix E

The Scales

The Scales

1. The Nature of Mathematics

1. Mathematics is mostly facts and procedures that have to be memorized.
2. Mathematics is thought provoking.
3. Everything important about mathematics is already known by mathematicians.
4. Mathematics is a non-creative subject.
5. Mathematics can be defined as computation.
6. If a friend and I got different answers to a math problem, one of us would have to be wrong.
7. Mathematics involves the active pursuit of patterns.
8. In mathematics, something is either right or it's wrong, there is no middle ground.
9. Mathematics involves lots of creative thinking.

2. The Individual as a Learner of Mathematics

1. When I get a good grade in mathematics, it's because I'm good at math.
2. When I get a poor grade in mathematics, it's because I haven't studied hard enough.
3. When I get a poor grade in mathematics, it's because I'm just not good at math.
4. I have great difficulty with time consuming math problems.
5. I can solve time consuming mathematics problems.
6. I am not capable of creating mathematical ideas.
7. I can do hard math problems if I am persistent and don't give up too soon.
8. My creative thinking abilities help me in math.
9. If I get stuck on a difficult math problem, I might as well give up because I will never solve it.

3. The Culture of the Mathematics Classroom

1. If I don't understand something in math, I would be able to talk to the teacher about it.
2. My mathematics teacher is aware of what I understand and do not understand in math class.
3. My mathematics teacher gives me help with things I do not understand.
4. Mathematics teachers are interested in teaching math only, they do not care about students as individuals.
5. I can communicate with my mathematics teacher.
6. I have some degree of personal contact with my math teacher.
7. In math class, students are expected to just sit back, listen, and absorb information.

4. How Mathematics is Best Learned

1. Mathematics is best learned by memorizing rules and procedures.
2. Mathematics is best learned by trying to understand the processes involved.
3. Mathematics is best learned by examining lots of different ways to answer the same question.
4. Mathematics is best learned by memorizing the exact procedures that the teacher uses.
5. The best way to learn math is to memorize all the formulas.
6. Mathematics is best learned by thinking things through individually.
7. Mathematics is best learned by discussing ideas with others.
8. The best way to learn math is to simply sit back and listen to the math lesson.
9. Time used to investigate why a solution to a math problem works is time well spent.

Appendix F

The Instrument

MATHEMATICS BELIEFS QUESTIONNAIRE

CODE Number _____ (Please use the last 4 digits in your
telephone number)

Math Course _____ Slot _____ Teacher _____

Instructions: Please fill in the following questionnaire regarding your beliefs about math. For each statement, circle **one number** on the scale from 1 to 10 to indicate your level of disagreement or agreement with that statement. For this scale, strongly disagree will be represented by a 1 and strongly agree will be represent by a 10.

strongly disagree < - - - - - > **strongly agree**

1. Mathematics is mostly facts and procedures that have to be memorized.
1 2 3 4 5 6 7 8 9 10

2. In math class, students are expected to just sit back, listen, and absorb information.
1 2 3 4 5 6 7 8 9 10

3. Everything important about mathematics is already known by mathematicians.
1 2 3 4 5 6 7 8 9 10

4. I can do hard math problems if I am persistent and don't give up too soon.
1 2 3 4 5 6 7 8 9 10

5. Mathematics is best learned by memorizing rules and procedures.
1 2 3 4 5 6 7 8 9 10

6. Mathematics is thought provoking.
1 2 3 4 5 6 7 8 9 10

7. I have some degree of personal contact with my math teacher.
1 2 3 4 5 6 7 8 9 10

strongly disagree < ----- > **strongly agree**

8. My creative thinking abilities help me in math.

1 2 3 4 5 6 7 8 9 10

9. Mathematics is best learned by trying to understand the processes involved.

1 2 3 4 5 6 7 8 9 10

10. Mathematics can be defined as computation.

1 2 3 4 5 6 7 8 9 10

11. Mathematics is best learned by examining lots of different ways to do the same question.

1 2 3 4 5 6 7 8 9 10

12. Mathematics is a non-creative subject.

1 2 3 4 5 6 7 8 9 10

13. When I get a poor grade in mathematics, it's because I haven't studied hard enough.

1 2 3 4 5 6 7 8 9 10

14. If I don't understand something in mathematics, I would be able to talk to the teacher about it.

1 2 3 4 5 6 7 8 9 10

15. Mathematics is best learned by memorizing the exact procedures that the teacher uses.

1 2 3 4 5 6 7 8 9 10

16. When I get a good grade in mathematics, it's because I'm good at math.

1 2 3 4 5 6 7 8 9 10

17. My mathematics teacher is aware of what I understand and do not understand in math class.

1 2 3 4 5 6 7 8 9 10

18. I can communicate with my mathematics teacher.

1 2 3 4 5 6 7 8 9 10

strongly disagree < ----- > strongly agree

19. If a friend and I got different answers to a math problem, one of us would have to be wrong.

1 2 3 4 5 6 7 8 9 10

20. If I get stuck on a difficult math problem, I might as well give up because I will never solve it.

1 2 3 4 5 6 7 8 9 10

21. The best way to learn math is to simply sit back and listen to the math lesson.

1 2 3 4 5 6 7 8 9 10

22. I have great difficulty with time consuming math problems.

1 2 3 4 5 6 7 8 9 10

23. Mathematics teachers are interested in teaching math only, they do not care about students as individuals.

1 2 3 4 5 6 7 8 9 10

24. When I get a poor grade in mathematics, it's because I'm just not good at math.

1 2 3 4 5 6 7 8 9 10

25. Mathematics involves the active pursuit of patterns.

1 2 3 4 5 6 7 8 9 10

26. Mathematics is best learned by thinking things through individually.

1 2 3 4 5 6 7 8 9 10

27. My mathematics teacher gives me help with things I do not understand.

1 2 3 4 5 6 7 8 9 10

28. I am not capable of creating mathematical ideas.

1 2 3 4 5 6 7 8 9 10

29. The best way to learn math is to memorize all the formulas.

1 2 3 4 5 6 7 8 9 10

strongly disagree < > **strongly agree**

30. In mathematics, something is either right or wrong, there is no middle ground.

1 2 3 4 5 6 7 8 9 10

31. Time used to investigate why a solution to a math problem works is time well spent.

1 2 3 4 5 6 7 8 9 10

32. Mathematics involves lots of creative thinking.

1 2 3 4 5 6 7 8 9 10

33. Mathematics is best learned by discussing ideas with others.

1 2 3 4 5 6 7 8 9 10

34. I can solve time consuming math problems.

1 2 3 4 5 6 7 8 9 10

35. What are your overall feelings about journal writing in math class?
Please write your comments below:

Appendix G

Follow-Up Survey Given to Teachers

TEACHER SURVEY

1. On the following two pages, please check off which journal questions (or relatively similar ones) you managed to use with your math class.
2. Did you use any questions of your own for the journal writing exercises? _____
If so, could you give a sample of one or two that you used:
3. On average, how often did you manage to get the students to write in their journals?
4. On average, how often did you mark the students' journals?
5. On average, how long did it take you to mark one class set of journal entries?
6. How many students were in the class?
7. Did you assign marks for the journal? _____
If so, how many marks, and were they "effort" marks or "content" marks?
8. What were the negative aspects of this experience?
9. What were the positive aspects of this experience?
10. If you have any further comments or suggestions, please indicate below:

JOURNAL WRITING TOPICS

Topic: The Nature of Mathematics

- _____ 1) Where do the rules in math come from?
- _____ 2) What is math? Brainstorm as many ideas as you can come up with.
- _____ 3) What subject is math the most like and why? What subject is math the least like and why?

Topic: The Individual as a Learner of Mathematics

- _____ 4) What is the most difficult math concept to learn so far? What is the easiest?
- _____ 5) (After a weekend.) How did you use math this weekend?
- _____ 6) (After completing a test.) How do you think you did? If you could study for the test again, what would you do differently?
- _____ 7) Describe your most positive or most negative experience with math.
- _____ 8) Describe your strengths and weaknesses as a math student.
- _____ 9) What are your goals in math? How do you plan to achieve these goals?
- _____ 10) Describe how the concept you learned today will be useful to you in the future.

Topic: The Culture of the Mathematics Classroom

- _____ 11) What do you think is the purpose of writing in a math journal?
- _____ 12) How do you feel math class is going so far?
- _____ 13) Describe your favourite math class.

Topic: How Mathematics is Best Learned

- _____ 14) Write a letter to a younger student explaining today's lesson so he or she will understand it.
- _____ 15) How does the concept from today's class relate to the other ones you have previously learned?
- _____ 16) If you had to teach this concept, what would you do to help students understand it?
- _____ 17) Your friend was absent from today's class. Summarize today's lesson so that he or she will understand what you learned.
- _____ 18) Choose the easiest and the most difficult question from the last assignment. How are they different? What makes one more difficult than the other?
- _____ 19) Create a problem for an upcoming test and solve it. Why do you think it would make a good test question?

- _____ 20) List as many of the different concepts from this unit as you can without looking in your notes.
- _____ 21) (Given a mistaken solution to a problem.) Explain to the person who solved this problem what they did wrong and how they can prevent making this same mistake in the future.
- _____ 22) (Given a term from a recent lesson.) Define this term in your own words.
- _____ 23) Create a word problem based on today's lesson and solve it.
- _____ 24) (Given a typical assignment question.) Write in words how you would go about solving this problem.
- _____ 25) (After a test) Explain how to correctly solve a problem that you made a mistake on when writing the math test.