Engaging Students in Mathematical Communication: Teaching for Understanding

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Abstract

Despite the documented importance of facilitating communication in the mathematics subject area, and teachers’ recognition of this importance, many teachers continue to practice traditional methods of teaching in their mathematics classrooms. Accordingly, this research paper looks at how effectively elementary teachers are implementing activities that promote rich verbal and written peer-to-peer and teacher-to-student communication as a way to teach for understanding in their mathematics classrooms. Using a qualitative research methodology, semi-structured interviews with 3 elementary teachers, ranging in years of teaching and training experience, have been conducted in order to determine the extent to which teachers perceive they are facilitating communication in their mathematics classrooms and perceived challenges which face these teachers along with other teachers in realm of education. The research conducted for this paper also sought out practical strategies that teachers may use so as to teach for understanding in the mathematics classroom through communication while dealing with the challenges to implementing student discourse. Through this research, it was discovered that teachers perspectives on, and experiences with, mathematics and student discourse, student attitudes and abilities, external factors, time, and the strategies which teachers employ in their mathematics classrooms as ways to facilitate student discourse, greatly affect the math talk which takes place within a classroom.

Key Words: Mathematics, student discourse, math talk, communication, discussion, challenges, and strategies
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Chapter 1: INTRODUCTION

1.1 Introduction to the Research Study

“Communication is an essential process in learning mathematics. Through communication, students are able to reflect upon and clarify their ideas, their understanding of mathematical relationships, and their mathematical arguments” (Ministry of Education, 2005, p. 17).

Communication is integral to an individual’s ability to succeed in today’s world. Without this skill, how can one socialize or express their opinions and thoughts clearly so that others understand what they are trying to say? How can one make connections to the world around them or debate a particular idea in order to develop a better understanding of the concepts they are being taught? Amanda Jansen (2006) stated that, “Involving students in discussion about mathematics can promote their active sense-making, as they have the opportunity to practice reasoning through speaking aloud, particularly when they are expected to analyze and critique the reasoning of others” (p. 409). The importance and benefits of facilitating communication in the mathematics subject area is generally recognized by most teachers. However, according to Denise B. Forrest (2008) out of 96% of eighth grade teachers who recognize the significance of communication in mathematics, only 76% of those individuals stated that they implement recommended practices into their own classroom practice. With this continued and recurring disconnect between learnt knowledge from professional development programs and implementing recommendations into practice, a clear issue persists. Too often are teachers entering into the realm of teaching with an overabundance of knowledge and increased professional duties, in addition to their home-life responsibilities, that it becomes easier to simply revert back to traditional mathematics teaching
practices of lectures and pencil and paper worksheets which lack opportunities to communicate mathematically.

It is important to note that, throughout this study, the terms *communication, mathematical talk, discussion* and *student discourse* are used interchangeably. In this study these terms are used to refer to any use of verbal or written mathematical vocabulary facilitated through peer-to-peer or student-to-teacher interactions and reflective activities as a way for students to portray their understandings of mathematical content.

1.2 Purpose of the Study

With the onset of an overabundance of teacher development programs, tools, and strategies offered to teachers, which promote the use of student discourse within the mathematics classroom in order to increase participation and understanding by students, research has found that there is a grave disconnect between knowledge learnt and classroom practices. According to Ross, Bruce, and Hogaboam-Gray (2006) the extent to which knowledge is transferred into practice varies between teachers, schools, and school boards. Depending upon the value that is placed upon mathematical talk, communication will be implemented in classrooms with varying degrees of effectiveness. However, it has become evident that much of the current research in this area does not discuss in detail any recommendations for teachers, by teachers, with respect to the ways in which beginning teachers can effectively facilitate practical activities that promote the use of mathematical talk while also dealing with the other pressures and responsibilities of the teaching profession. The particular focus of research in this area is upon explaining whether there truly is a disconnect between knowledge and professional development and implementation in mathematics classrooms.
Many resources available to teachers, including Marian Small’s (2013) “Making Math Meaningful to Canadian Students, K-8,” provide many recommendations to teachers in regards to how communication may be facilitated in the mathematics classroom. Yet, these resources do not take into consideration the difficulties which today’s teachers face in the implementation phase of these recommendations. For this reason, the purpose of this study is to raise awareness of this disconnect, attempt to determine the possible difficulties of facilitating effective mathematical discussion and to seek out recommended strategies to deal with the difficulties that may emerge from this research, so that, hopefully, more effective mathematics teaching practices may be implemented in all classrooms in the future. In this way we hope to be able to ensure that all students are receiving the same opportunities to develop mathematical communication skills and develop broader understandings of the concepts being taught in class.

1.3 Research Questions

Taking into consideration the possible disconnect between teachers’ knowledge and what they put into practice, the overall goal of this study was to seek out the ways in which teachers of varying years of teaching experience can facilitate activities that promote the use of student discourse and math talk, either peer-to-peer or student-to-teacher written and verbal communication in and about mathematical problems and students’ thinking, so as to teach for understanding in their mathematics classrooms. In addition, this research paper sought out effective strategies that teachers may use in order to battle the many pressures upon teachers to fulfill a multitude of duties including assessment, reporting, and extra-curricular activities while also effectively facilitating communication in their mathematics classrooms. Accordingly, the following sub-questions assisted in guiding this study of the facilitation of communication in mathematics classrooms:
What is the value that teachers place on facilitating student communication in mathematics classrooms today?

To what extent are teachers supporting rich communication- verbal and written peer-to-peer and teacher-to-student communication- in their mathematics classrooms while continuing to fulfill other duties and responsibilities of their profession?

Are there any factors that may hinder a teacher’s ability to infuse rich mathematical discourse in their mathematics classrooms? If so, what are they?

What strategies or suggestions can established teachers provide to colleagues in the field of mathematics in regards to facilitating mathematical discourse in their own classrooms so as to increase student participation, engagement and understandings in and about mathematics?

1.4 Background of the Researcher

As a young student in elementary and secondary school, mathematics was one of my strongest subject areas. I often knew the steps to take to achieve a specific answer; however this did not exactly translate into understanding why I was taking these measures. In spite of this lack of conceptual understanding, teachers often encouraged that I assist fellow classmates with their own mathematical understandings. Though this can be seen as a form of peer-to-peer communication in the mathematics classroom, in my opinion, it was not facilitated very well. Assisting others allowed me to communicate my mathematical thinking to peers; however these peers were unable to communicate their thoughts back to me. They simply listened to how I got
the answer and then did exactly what I was doing, step-by-step, because they knew it would get them the correct answer. In addition, these students would often not participate in math because they did not understand the *Big Ideas* that were being taught as the communication that should have been taking place was not being facilitated effectively.

One would assume that asking students to discuss mathematics can be fairly easy once the students get into the junior grades. Who does not know how to discuss thinking at this age? However, while attempting to prepare a mathematics unit for a primary/junior class as a fulfillment for a Master of Teaching first year course, it became very evident that finding ways to engage students in mathematical communication, while refraining to simply provide them with constant handouts, is an extremely difficult task. This task also became extremely daunting when not only were efforts required to complete this task, but efforts were also required to complete other assignments simultaneously. It was at this point when it became very clear that, in relation to the teaching profession where teachers must plan for all subject areas simultaneously, while also fulfilling other duties and responsibilities such as reporting on assessment and assisting with co-curricular activities, focusing upon engaging students in rich mathematical communication would not be an easy task.

In my practice teaching I have witnessed the benefits of promoting multiple lines and forms of communication in the mathematics classroom through the use of KWL charts describing the students’ knowledge on a topic, what they would like to learn more about and what they have learned after a particular lesson or unit, Think, Pair, Share strategies where the students think about a question or topic and pair up with a peer after a moment to share their thinking, interactive mathematics journals in which students can engage in two way communicate with both their teachers and peers, and teacher-student conferences. However, I had realized very quickly the
difficulties that accompany the implementation of these strategies and facilitation of communication in the mathematics classroom on a daily basis. In this way I had also learnt that mathematics is a subject in which the important use of discussions about the content can be easily overlooked and it is far too easy to simply provide students with worksheets to complete so as to save time and focus efforts upon other priorities. Thus, this research project seeks the possible difficulties that teachers may have with facilitating effective communication and how effectively elementary teachers perceive they are implementing activities that promote student discussions about mathematics and their thinking in and around the subject matter, so as to teach for understanding in their mathematics classrooms.

1.5 Overview

This Master of Teaching Research paper is organized into 5 chapters along with a section for references and appendices. Chapter 1 includes an introduction to the background of this study, why this is important to the field of education, the research questions that pertain to the study following, as well as my reasons for delving into the topic area at hand. Chapter 2 provides a literature review outlining the research that supports my claims and rationale for this study. This chapter also outlines the importance of communication in the mathematics subject area along with a discussion of the research which supports the continued disconnect between knowledge and implementation in the mathematics classroom. Chapter 3 outlines the methodology and procedures that had been followed throughout the duration of this study. This chapter provides a description of the participants and the methods and instruments that were used to collect and sort through the data pertaining to this study. After conducting the interviews with the 3 participants of this study, the findings which emerged from the data have been outlined in chapter 4, organized by headings and sub-headings. The chapter following then provides a discussion of the findings,
implications for the teaching profession, limitations of the study, and a brief list of suggestions for further studies. Finally, included is a list of references used throughout this proposal and appendices including interview ‘questions and a letter of consent used for the interview process.
Chapter 2: LITERATURE REVIEW

2.1 Why Communication?

Communication in mathematics has been given a great deal of attention over the past 20 years. According to a group of researchers from Texas A&M University in the United States, “Teaching is an activity that presumes some form of communication” (Ezrailson, Kamon, Loving, & McIntyre, 2006, p. 278). With this in mind, these researchers went on to state that students will only retain 20% of what they hear, 30% of what they see and 50% of what they see and hear (Ezrailson et al., 2006, p. 278). However, when teachers focus on interaction and communication in the classroom, students will retain 90% of what they say and do as they engage in discussions (Ezrailson et al., 2006, p. 278). It is clear in this research that communication is an important factor in enhancing the quality of students’ learning and understanding in the mathematics subject area. To further demonstrate the significance of communication in mathematics, the National Council of Teachers of Mathematics (NCTM) (2000) had included a communication standard as part of the Principles and Standards for School Mathematics. Recognizing the importance of communication as a way to consolidate the students’ knowledge and understandings of course materials, the Ontario Ministry of Education (2005) also mandated that communication be identified as one of the seven mathematical processes described in the Mathematics curriculum document. In this way, communication has been placed at the forefront of the mathematics curriculum so that all teachers recognize the importance of this skill and work towards providing students with ample opportunities to engage in mathematical talk. Jessica Pierson Bishop (2012) also discussed, “The ways in which we talk and interact with each other are powerful because they affect who we are and who we can become with respect to mathematics” (p. 70). When students
are able to effectively engage in discussions about mathematics, they will be better able to build confidence and see themselves as mathematicians.

According to the Ontario Mathematics Curriculum (2005), “Communication is the process of expressing mathematical ideas and understanding orally, visually, and in writing, using numbers, symbols, pictures, graphs, diagrams, and words” (p. 17). In this respect, communication can take the form of both verbal and written responses to the materials and activities provided to students which will allow them greater opportunities to gain conceptual understandings of mathematics. Erna Yackel and Paul Cobb (1990) had mentioned in their work, “Few, if any, would disagree with the view that learning occurs not as students take in mathematical knowledge in ready-made- pieces but as they build up mathematical meaning on a basis of their experiences in the classroom” (p. 34). Also, in her research on the effects of communication on the participation of seventh graders in their mathematics classrooms, Amanda Jansen (2006) found that “a classroom discussion with a focus on correct answers may be more threatening than one that emphasizes understandings” (p. 410). Through this research it is clear that communication is critical to the success of our students in today’s classrooms as they will have more opportunities to develop conceptual understandings of concepts through physically and verbally engaging in their learning. Erna Yackel (1990) stated that, “These opportunities have their genesis in social interaction. As students participate in the discourse… they learn to develop mathematical explanations and justifications and engage in what is typically termed analytical reasoning” (p. 35). Discourse provides students with opportunities to discuss, explain, and justify their thoughts, pose questions to resulting answers that they do not understand, and simply make an attempt to answer problems.
In their study on primary grade students making mathematical arguments, Joy Whitenack and Erna Yackel (2002) discussed that “All students can benefit from these discussions, including the student who is explaining and the others who are participating in the discourse. When asked to explain or justify their thinking, students can revisit their mathematical ideas” (p. 525). In this way rather than simply quashing their thoughts and ideas by focusing solely upon obtaining the correct answers, students will be given greater opportunities to be creative in their thoughts and focus on developing their understandings of mathematical processes and concepts. On this point, Yackel (2001) stated that “An emphasis on explanation and justification in a mathematics classrooms leads to mathematics learning that emphasizes reasoning” (p. 14), while Yackel, Cobb & Wood (1991) also found that,

…attempts to resolve conflicts lead to both the opportunity to reconceptualize a problem and thus construct a framework for another solution method, and the opportunity to analyze an erroneous solution method and provide a clarifying explanation. These types of discussion-based learning opportunities do not typically occur in traditional classroom settings and are qualitatively different from the opportunities that do not arise in traditional settings where children typically do not engage in mathematical discussions with each other but work individually to complete many exercises by repeating a method demonstrated by the teacher. (p, 401-402)

According to Yackel, Cobb and Wood (1991) there is great benefit in replacing traditional forms of mathematics teaching with strategies which are more conducive to facilitating student discourse in mathematics.
2.1.1 Positive Aspects of Communication

In an article outlining the benefits of using communication in the mathematics subject area, Judith Mumme, a researcher from the University of California, and Nancy Shepherd, an employee of the Goleta Union School District, (1990) stated that:

Communication in and about mathematics serves many functions. It helps to (1) enhance understanding, (2) establish some shared understandings, (3) empower students as learners, (4) promote a comfortable learning environment, and (5) assist the teacher in gaining insight into the students’ thinking so as to guide the direction of instruction. (p. 18)

Facilitating effective peer-to-peer and student-to-teacher communication is an important aspect in the teaching of mathematics. This not only allows students to consolidate their knowledge and understandings of concepts through discussions, but also gives the students multiple opportunities to build confidence in a supportive environment that is open to discussing new and creative thoughts and conducive to supporting and empowering students with different abilities and strengths.

In support of Mumme and Shepherd’s (1990) research of the importance of communication in the mathematics subject area, Small (2013), a researcher in the area of mathematics in kindergarten to grade 12, had also stated that, “Communication in mathematics, whether silent self-talk or communication with peers or a teacher, is essential to students as they learn; it is also a critical assessment tool for teachers” (p. 119). In addition, Bishop (2012) stated, “Monitoring student talk enables one to identify who participates and how, who does not participate and why, and what kinds of mathematics identities students are enacting” (p 69). Both Small (2013) and Bishop (2012) confirmed Mumme and Shepherd’s (1990) research on the importance that
communication plays in facilitating students’ understandings and providing teachers with multiple opportunities to assess students’ abilities in order to further guide mathematics instructions so that it is in line with the students’ current understandings of the concepts being taught. Communication, both verbal and written, allows teachers to immediately hear and see the students’ current abilities and understandings so that immediate feedback and, if necessary, immediate intervention can be provided so as to guide the students in the correct direction. In this respect, Madelyn M. Williams and Tutita M. Casa (2012) had stated that, “Their writing serves as a culminating activity that allows me to better assess the depth of each students’ understanding following class activities and discussions” (p. 314).

**2.1.2 Drawbacks to Communication**

Though few in numbers, facilitating communication in the mathematics classroom does pose potential drawbacks for teachers. Ezrailson et al. (2006) stated that, “True two-way communication allows students to reveal thinking, actions and questions in a way that could be frightening to the instructor” (p. 279). Often teachers may become discouraged from facilitating communication due a lack of control over what is discussed in the mathematics classroom and due to the comments or questions that students may pose at any given moment. This presence of the unknown becomes very frightening for many as the control of what is being learnt leaves the hands of the teacher and is placed in the possession of the students.

To add to the above drawback, though not discussed comprehensively in her research, Bruce (2007), mentioned that, due to the interactive nature of mathematical talk and the encouragement for the exchanging of ideas between peers, some students may seem to think that peers are stealing ideas when they use the information discussed in class as their own consolidated
understandings. When students begin to feel this way, a problem with communication channels may persist. Students may begin to restrict themselves from providing input in discussions so that others do not steal their ideas. In this way this becomes a drawback to communication in the mathematics classroom as students will no longer participate in mathematical talk and therefore may revert the classroom back to traditional ways of teaching with a lack of interaction, unless carefully remedied.

2.2 Is Enough Communication Being Facilitated in Mathematics Classrooms?

Though communication is understood by many to be important in building understanding for students in the mathematics classroom, Forrest (2008), found that, “These interactions have not been typically found in mathematics classrooms” (p. 23). Teachers may gain an abundance of knowledge and strategies in regards to the importance of facilitating both verbal and written mathematical discussion; however this knowledge does not often emerge enough in teaching practices. As discussed earlier in this paper, the research of Forrest (2008) had found that of 96% of teachers surveyed in the United States stating that they have knowledge of the importance of mathematical talk, only 76% of these individuals stated that they implement this knowledge into practice. It is evident here that there is a disconnect in the teaching profession that a large portion of teachers are not transferring recommended mathematics strategies into their own teaching practices. With this taking place, students’ education begins to suffer as they may not receive proficient opportunities to practice mathematical talk and, in turn, build their own understandings of the materials at hand so that they achieve higher success rates.
2.2.1 How is Communication being hindered in the Mathematics Classroom?

Bruce (2007), stated that teachers face many challenges when attempting to facilitate communication in the mathematics classroom including; “complexities of teaching mathematics in ways they did not experience as students; discomfort with their own mathematics knowledge, lack of sustained professional development opportunities; and lack of time, especially in face of curricular demands” (p. 2). In support of Bruce’s statement, Ezrailson et al. (2006) also stated that, “For those of us who have not been taught, seen or experienced this means of instruction, it may seem perplexing” (p. 278). Without having experienced this form of teaching in a mathematics classroom, it is very easy for teachers to simply teach the way they have been taught in the form of paper-and-pencil tasks which do not promote the use of communication between peers and between students and teachers. It is very difficult for teachers to break out of their comfort zones and teach in new ways when they do not have sufficient practice with teaching mathematics through the use of various communication channels. In effect, this hinders their abilities to effectively facilitate communication in the mathematics subject area.

In a study on the different contexts and forms of communication that may take place between both students and teachers and students and peers, Nuhrenborger and Steinbring (2009) found that the quality of communication will differ given the context in which the communication is taking place. In this respect, the quality of communication that will emerge in the mathematics classroom will gravely depend on the atmosphere of the classroom and the relationships between peers and between students and teachers. If the teacher values a supportive environment which supports opinions and positive interactions between individuals then communication will prevail effectively. However, when discussion and interaction in the classroom is not given a high degree of importance, and the social environment is not a positive one, often students will sense this
negativity towards hearing opinions and the lack of interpersonal relations and, therefore, will not wish to participate in class discussion or activities.

In addition to the above hindrances, “In the face of curricular demands, the time required for facilitated interaction has been identified by teachers as an inhibitor to implementing math-talk” (as cited in Bruce, 2007, p. 2). With so little time and an overabundance of curriculum expectations for each subject area, it is extremely difficult to find the time to effectively fulfill all other duties and also spend time on preparing for and facilitating mathematical communication. In addition to this, teachers are not only responsible for teaching curricular expectations but they are also responsible for fulfilling other duties in and around the school such as co-curricular activities, yard duty, and extra-curricular activities, not to mention home-life responsibilities. In this respect, how can teachers find the time to effectively support communication in the mathematics classroom?

2.3 What Does the Research Propose as Suggested Strategies for Promoting Communication in the Mathematics Classroom?

Identifying the challenges that teachers may have with facilitating communication in the mathematics subject area, in her research, Bruce (2007) provided five strategies that may be used to effectively engage students in mathematical discussion: “1) use of rich math tasks; 2) justification of solutions; 3) students questioning one another; 4) use of wait time; and 5) use of guidelines for math-talk” (p. 3). These strategies are suggested to teachers as a way to mend the disconnect between research and practice that many teachers experience. With these strategies, teachers are encouraged to pose problems with multiple solutions so that students are given opportunities to debate and discuss solutions. In addition teachers should allow students ample
time to justify their answers to classmates and question each other so as to gain a broader understanding of others’ processes and thoughts about various problems, while also providing students with time to consolidate their own thoughts prior to answering questions aloud. Teachers are also encouraged to provide students with a guide in regards to what mathematical talk should sound like and what is the criteria that is expected of the students when they are discussing mathematical concepts. This last strategy also provides teachers with a list of criteria that may be effectively used to assess the students as they communicate.

In comparison to these suggested activities, Marian Small (2013) dedicated a chapter of her text to communication in the mathematics classroom. Along with Bruce (2007), Small (2013) discussed the importance that peer-to-peer communication, questioning, and reflection plays in mathematics and the opportunities for learning that can emerge from posing open-ended questions and math problems with multiple solutions that may be discussed and debated. She also, stressed the importance of sharing with students the criteria that will be used to assess their math talk so that they too have an opportunity to understand what is expected of them so that they may succeed. In comparison to Bruce’ (2007) work, however, Small (2013) also provided a comprehensive list of ways that verbal and written communication may be brought into the classrooms, and strategies and prompts that can be used with students in order to effectively engage the students in mathematical talk, such as mathematics journals and thoughts for discussion. Though a multitude of strategies are listed in Small’s text, it is still very difficult to find the links between implementing these strategies while also being able to deal with a lack of time and an overabundance of other pressures that are placed on teachers on a daily basis.
2.4 Limitations of the Research

In the research, there is much evidence that brings light to the importance of communication in the mathematics classroom in order to teach for understanding. There are also numerous strategies available to teachers in regards to how to support communication. However, there continues to be insufficient research upon teachers’ personal struggles with implementing this knowledge into practice and a lack of recommendations which recognize the overabundance of duties and responsibilities facing those in the teaching profession. Strategies for implementing communication in the mathematics classroom, or any subject area for that matter, seem to be studied and documented in research as separate entities, stating the steps that teachers should take to implement these strategies without taking into consideration all other subject areas and duties that also require paying attention to. With this in mind it will be beneficial to this area of study, and to beginning and experienced teachers, to obtain a list of practical strategies that take into consideration other pressures that teachers may have in addition to those in the mathematics subject area. In this way, it is hoped that teachers will be able to effectively facilitate mathematical talk and provide students opportunities to build conceptual understandings.

In addition to these limitations, much of the research concerning the facilitation of communication in the mathematics classroom seems to be grounded in research from the United States. In this respect, though strategies used in the United States may be applied to Canadian schools, it is evident that a Canadian perspective should be employed in this area of research so that Canadian teachers are also given the opportunity to personally relate to the research and be able to see the clear links that can be made to their own teachings in Canadian schools.
2.5 Summary and Recap of the Research Questions

While it may be challenging to facilitate, as a future teacher of mathematics, I agree with the researchers that communication is critical in facilitating students’ understandings of mathematical concepts. The benefits of mathematical discourse far outweigh the challenges that may face teachers in the phases of facilitation. However, as can be seen from much of this research, there is a lack of discussion upon teachers’ abilities to effectively facilitate communication in the mathematics classroom while maintaining other responsibilities and duties and effectively teaching all other subject areas in the middle school grades. In addition there is also a lack of a Canadian perspective in this subject area. To this respect, the research questions that will continue to be furthered in this proposal include: what is the value that teachers place on facilitating communication in mathematics classrooms today; to what extent are teachers supporting rich communication- verbal and written peer-to-peer and teacher-to-student- in their mathematics classrooms while continuing to fulfill other duties and responsibilities of their profession; what factors hinder a teacher’s ability to facilitate a communication rich mathematics program in their classrooms; and in what ways can teachers facilitate communication in their own classrooms so as to spark learning enthusiasm amongst students in the mathematics subject area while working under the constraints of other responsibilities of the teaching profession?
Chapter 3: METHODOLOGY

3.1 Procedure

In order to determine the perceived extent to which teachers transfer their knowledge of mathematical communication strategies into practice, a qualitative research methodology had been used. Research for this project looked towards finding practical strategies that teachers may use so as to teach for understanding in the mathematics classroom through communication, while also being able to deal with the added pressures of their day-to-day activities. In this research project a literature review was conducted to discuss the research that is currently available in this topic area. Semi-structured interviews with three elementary teachers in a public school board in Ontario, ranging in years of teaching experience in the mathematics subject area, had been conducted. These interviews were used to collect information on the extent to which communication is being facilitated in elementary mathematics classrooms today and the suggested strategies that these teachers may have for beginning teachers in dealing with daily pressures of the teaching profession while also effectively facilitating mathematical discourse.

Two interviewees had been contacted through email, while one interviewee was contacted in person to request participation and discuss their interests in participating in this study. After taking interest in this research study, each participant was provided with a letter of consent for the interview process (Appendix A), which had been printed on official OISE letterhead, read over and signed by each participant. It had been stressed to participants that, if they wish, they would be able to discontinue their participation in this study even after the interview had been conducted. Further communication with the interviewees prior to the physical interview had been conducted through the email and telephone number provided in the consent form.
The Interview questions (Appendix B) had been divided into 6 sections ranging from questions regarding the background of the participants and suggested strategies that the teachers might have for beginning teachers facilitating mathematical communication. These interview questions had been reviewed and approved by a research supervisor prior to conducting the interviews.

Throughout the interviewing process, two of the interviews had been conducted face-to-face, at a location of the participants’ choice so as to provide the interviewees with comfort and ease, while one interview had been conducted using Skype technology at the convenience of the interviewee. The interviews had been audio-recorded using an application on a cell phone and minor notes were also taken throughout the interview process in a discreet manor. Prior to the interview, participants had been provided with a list of the research questions through email and at the time of the interview they had been provided with a hard copy of the same questions. The duration of each interview ranged between 30 – 40 minutes.

Once the interviews were completed, the audio-recordings had been transferred to a personal computer, played and transcribed using a computer audio-player program and word document. The information was then analyzed and coded for emerging themes. Once themes were determined, this information had been compared and contrasted to the literature review provided in this study and a rough draft had been written. After being discussed and reviewed several times with a research supervisor and research group members, a final write-up of this research paper had been created, submitted to the research supervisor to be signed off on and uploaded to T-Space upon being signed as completed.
3.2 Instruments of Data Collection:

For this research project, qualitative research was conducted. Turner (2010) stated that “Standardized Open-Ended Interviews” are appropriate to use with qualitative research due to the quality of information that these questions extract (p. 756). With this method, Creswell found that it is very time consuming and it is difficult to code the data collected (as cited in Turner, 2010). However, Gall, Gall and Borg (2003) had found that this method also allows for a reduction of biases in the research which will benefit the study (as cited in Turner, 2010, p. 756). By using this form of interviews, the questions had been structured in an open-ended format so that participants were able to contribute as much, or as little, information as they saw fit in answering the questions. The length of the interviews ranged between 30-45 minutes and had been conducted in person and over Skype, one-on-one. The interview questions developed had first been reviewed by a research supervisor and include questions such as: what does communication mean to you as a mathematics teacher; in what ways do you support communication in your own mathematics classroom; and what techniques or activities do you use in your classroom to facilitate communication about mathematics? These questions, along with the rest of the questions included (Appendix B), had been organized into 6 categories ranging in scope from background information of the participants to suggested strategies that the participants may have for teachers. These questions had been used as a guide for the interviews, as some questions, though very few, changed throughout individual interviews so as to gain greater insights from each interview participant.

3.3 Participants

For this research project, three qualified elementary school teachers had been interviewed. The selection of these three participants were based upon the following criteria: experience with
teaching in the mathematics subject area, varying years of teaching experience in the mathematics subject area, and whether the individual facilitates the use of communication in their mathematics classroom. Most importantly, however, the participants chosen had a genuine willingness to participate in this research study. Given the nature of this research project, the interviewees were required to have experience with teaching in the mathematics subject area and with supporting mathematical communication so that they were able to provide greater insights into their experiences with facilitating communication in the mathematics subject area. Varying years of experience on the part of the interviewees was also important so as to provide perspectives on this topic area from teachers whom have had varying experiences and experienced varying degrees of professional growth in their teachings. By meeting the criteria outlined here, the participants chosen had been able to provide quality information and insights into the topic area of this study.

3.4 Data Collection and Analysis

After the interviews were conducted they had been transcribed in a smooth verbatim manner, typing only the proper words that had been spoken, by listening to the audio-recordings and typing the transcription into a word document. I had then begun reading and re-reading these transcribed interviews to search for themes within the data that had either confirmed or disconfirmed the research conducted in the literature review for this study. Throughout the reading process, as themes and sub-themes emerged, they were typed into a chart which organized the three participants’ responses across the themes so that they could be easily analyzed for the findings indicated in Chapter 4. In addition to this, as important quotes were found throughout the participants’ transcribed interviews, they were underlined and a star was placed beside them so that, they too, could be used in the findings chapter.
3.5 Ethical Review Procedures

Throughout the process of conducting and writing this research project, I had followed the ethical review procedures as outlined for the Master of Teaching program. Each participant of this study had been obtained on a voluntary basis and was provided with a letter of consent for the interview (Appendix A) to read and review prior to participating in the interviews. The letter had been reviewed in the presence of both the participant and the interviewer so that he or she clearly understood the purpose and implications of this study. In addition, it had been explained explicitly to the participants that, if at any time during the process of completing this project they happened to become concerned with their participation in this study, they had the option to withdraw their participation in this study.

Prior to the interview process, participants had been made aware that any identifying information obtained about them would be strictly confidential between the interviewer and the interviewee. Participants’ names were referenced in this paper by pseudonyms and the specific school and school boards of which they were affiliated with had also not been identified. It had been made clear that all raw data collected would be stored securely on a password protected computer and any written or printed notes were held in a dedicated notebook to this study that had been kept in a safe and secure place at all times.

Upon completion of this research, a research supervisor had reviewed this study to be sure that the anonymity of all participants was kept at all times so as to protect the participants from any type of personal harm or professional consequences. At the completion of this project and its submission to T-Space, participants had been made aware, both at this point and prior to the collection of raw data, that all information obtained which contained identifying information of the interviewees had been destroyed so as to maintain the anonymity of all participants.
3.6 Limitations

The potential limitations that have emerged from this research include the small sample size of teachers chosen for the interview process, which, in effect, have restricted this information from being generalizable to a larger population. Also, due to the short period of time allotted to completing this research project, much of the collection of information, literature and research questions were required to be carefully selected and restricted to a manageable size to be sure that this project was completed in a timely manner within the duration of a two year Master of Teaching program.

In addition to these basic limitations of the study, the fact that information strictly came from a teachers’ perspective allowed this process to become subjective in its nature. Without having the input of students and their thoughts on how communication influences their own understandings of mathematical content and the extent to which they themselves feel that communication is being facilitated in the classrooms, it is difficult to understand the true effects of teacher facilitated communication in the mathematics classrooms on students’ learning.
Chapter 4: FINDINGS

Throughout this chapter, pseudonyms were used to make reference to the 3 elementary teachers’; Victoria, a grade 1 teacher; Nicole, a grade 3 teacher; and Terry, a former grade 6 and 7/8 math teacher, whom were participants in this study.

The following findings have been divided into five parts. First, the participants’ understandings of student discourse and the perceived importance that these teachers place upon facilitating student communication in mathematics classrooms today are laid out so as to provide a foundation for the findings which follow. Next, the interviewees’ perceptions of their own abilities to facilitate student discourse in their classrooms are discussed, followed by the perceived challenges that these teachers face when incorporating math talk in the classroom. Finally, a few strategies and suggestions from the participants are provided in order to offer practical advice to teachers that have or will be entering into the realm of teaching mathematics.

4.1 Understandings of Student Discourse

4.1.1 What is Student Discourse?

While undergoing interviews with the three participants of this study, it was discovered immediately that, when asked about what student discourse meant from their perspectives, in line with the research done by Forrest (2008), each of these teachers had a clear and coherent understanding of student discourse. According to the three participants, student discourse pertains to students explaining their own understandings, along with developing shared understandings, of mathematical concepts and Big Ideas with members of the classroom community, through both verbal and written lines of communication. In her interview, Victoria discussed that, “It’s really about conversing about students’ ideas around math and particular questions and their thinking
and expressing what they know and explaining how they understand ideas and discussions - agreeing and disagreeing with others.” Each of the participants, in accordance with Jansen (2006), agreed that students come to develop a deepening understanding of mathematical concepts when they are given multiple opportunities to discuss their mathematical understandings, question, and engage in conversation with peers. Nicole stated that, “Student discourse is where you get the real world connection and they can actually just make different connections during that.” It was Nicole’s understanding that students require opportunities to discuss their own experiences and understandings with each other so that they can make connections between mathematics and the world around them through questioning, agreeing, disagreeing, and responding to their peers.

4.1.2 A Change in Focus

Though written communication was discussed as a form of mathematical talk at brief points throughout each of the interviews, it is interesting to note that a great majority of the data collected throughout these interviews pertained mainly to verbal student discourse. It is also interesting to point out that, of all of the participants in this study, in accordance with Ross, Bruce, and Hogaboam-Gray (2006), Victoria was the only teacher to discuss the influence that school boards often play in determining the focus of subject matter programs in schools:

Sometimes it’s more of an initiative in the board… because it used to be about writing in math and communicating their thoughts in writing, not so much verbally. And so, it used to be more the student to themselves and then to the teacher. Not too often we would share those ideas amongst each other. So now we are communicating more…
Victoria clearly highlighted the key role that school boards maintain in determining the focus of mathematics programs. In addition, through her discussion she had also identified a problem within this prior focus on the written aspects of student discourse. She discussed that, when communication is strictly in written form, this eliminates students’ opportunities to interact with peers and engage in conversations where students are able to respond to their peers’ questions and answers and teachers are able to capitalize on teachable moments that may arise through these discussions.

### 4.2 Perceived Importance of Math Talk on Student Learning

#### 4.2.1 Individual Learning

Among the three elementary teachers whom took part in this study, there was clear understanding, and agreement with the Ministry of Education (2005), that implementing student discourse is detrimental to the development of students’ mathematical understandings. In his interview, Terry stated,

> Doing a bunch of arithmetic questions by simply punching them into a calculator sometimes is mindless. You’re looking at one number, punching it in and getting another number. You’re not really thinking of how that number came about. But if a student can explain a word problem…the steps that they took, and explain how they got an answer, to another person, whether it’s a teacher, the class, or another peer, that shows that they have a deeper understanding of the math problem.

According to this junior/intermediate teacher, providing problems that could simply be solved by a calculator did not allow students to use their brain power and engage in mathematical discussions with peers in order to explain their understandings. It was often through verbalization that students
truly got a clear picture of their own understandings. Victoria added, “It’s that metacognitive part… when they have the opportunity to externalize it then they deepen their [individual] understanding.” This verbalization also allowed students to get the big picture, make connections to their own lives and become successful in mathematics (Nicole). Victoria further added that “[with a lack of engagement or interaction between them] they’re more likely to not internalize what you are doing or teaching.” In this regard, the participants discussed that only when students had multiple opportunities to practice engaging in discussions about mathematics had they become more confident in engaging in the process of student discourse and internalized and gained a better understanding of the concepts at hand.

According to Nicole and Terry, teachers need to leave opportunities for students to explore concepts and problems on their own without the teachers explaining, step-by-step, how to go about solving problems. In this way, Terry suggested that the students do not just passively do what the teacher tells them to do to solve the problem, but it encourages them to use their own brains and come up with their own solutions and formulations to mathematical problems. Nicole also discussed that it was beneficial for students to not always be set up for success in determining solutions so that they were forced to discuss and come to understand either a new way of formulating an answer or why a solution could not be found. According to Nicole, students gain better understandings when they are encouraged to think critically about the problems they are solving and consolidate their knowledge as they verbalize their own ideas and/or frustrations.

It is interesting to note here that Victoria, a grade 1 teacher, did not directly discuss the ability to allow students to simply explore concepts on their own. Victoria did acknowledge, however, a problem, stating that, “…when students’ come and they haven’t had any opportunities, really, to explain their thinking… they really have to be taught and practice.” Victoria understood
the importance of allowing students to engage in student discourse and the exploration of problems, however, she also took note of the fact that at such a young age students need to be taught to engage in student discourse and must be provided with many opportunities to practice in order to gain the great benefits from mathematical communication.

4.2.2 Student Engagement

Among the participants, it was clear that the level of understanding in regards to the benefits that student discourse provides to the engagement of students in this subject area was high. Consistent with all participants and the research done by Yackel and Cobb (1990), engagement was increased when students were able to discuss their understandings with their peers through group activities and think-pair-share (turn and talk) discussions. Nicole discussed that, “The kids are excited when they get to work in a group because they want to talk to each other.” She also stated, “Students with different abilities sit together and talk about the math because they are all friends…students are more engaged when they are just working it [math problems] out with their friends.”

The data collected through these interviews, in addition to the research done by Ezrailson et al. (2006) in which they discussed that students are not as engaged in their learning when there is a lack of mathematical discourse taking place, demonstrated that student discourse is key in maintaining engagement. Without this communication and interactivity between the students, their attention will be lost due to their often, shorter attention spans. According to Victoria, “You can only keep the engagement of grade 1’s for 10-15 minutes until you’ve lost them if there’s no engagement between them.” When teachers provide mathematics problems that require no communication or active participation, students may become disinterested in the subject. Terry
discussed that this also happens at the intermediate level when student discourse is not present. He went on to discuss his experience:

I’ll be honest, the first year that I taught mathematics I did not really implement student discourse right away. I actually had students do problems on their own, and to me the class was very quiet and very mechanical and the students did their work but they weren’t actively engaged. They were just passively doing it. It’s like they just came in and they read the problem, did it, and then they left. A few months into my first year teaching mathematics I started to implement more student talk and I could see the students got excited trying to solve the problem. How I saw engagement was when I actually heard the students in a group arguing with each other about how to solve the problems and they seemed to enjoy that. I mean, arguing, not in a bad way, but arguing to try to solve the problem together because they had different ideas.

Though Terry’s primary teacher training focused on mathematics, it was not until after Terry’s initial experience with teaching mathematics that he determined the benefits of using communication to increase engagement and build students’ mathematical understandings.

4.2.3 Language Development

Though each of the participants of this study had at least a small population of the class whom were English Language Learners at the time, Victoria was the only teacher to discuss the benefits of mathematical discourse and communication on the development of students’ language. She mentioned that, when students are constantly exposed to the language of mathematics and are given multiple opportunities to verbalize their understandings, they will be better able to build
their vocabularies and increasingly be able to engage in conversations with peers about mathematics and all other areas of interest. With this she stated, “If they start communicating in grade 1, by the time they get to grades 3 and 4 they may be better off.” According to Victoria, beginning to facilitate student discourse in the primary grades will build a solid foundation for the students when they enter into higher grades and are expected to explain their understandings of mathematics more articulately.

4.3 Participants’ Facilitation of Student Discourse in their Own Classrooms

4.3.1 Participants’ Creation of Positive Classroom Dynamics

In comparison to the literature review, the findings, which emerged from this research, support Nuhrenborger and Steinbring’s (2009) understandings that the quality of communication that emerges in mathematics classrooms depends upon the atmosphere of the classrooms and the relationships between teachers and students. All participants believed that classroom dynamics played a large part in determining the amount of mathematical communication that emerged within a classroom. According to Nicole, “The first two months of school is just setting up that environment where they know that they can do it [mathematics],” while Victoria agreed that a culture must be set up in order to facilitate student discourse. She also went further to state that, in her grade 1 classroom, it was already part of the culture to talk about how to be a good audience, a good listener, and a good speaker, meaning that all students have a clear understanding that incorrect answers are acceptable and a good audience member does not criticize any other member of the classroom community. With this, Terry also discussed the importance of setting up a culture where students are not embarrassed or singled out in his grade 7/8 classroom, when they provide incorrect answers, so that students do not become discouraged from participating in mathematical
discussions. In order to battle the urges that students sometimes have to criticize or embarrass peers when they provide incorrect answers, Nicole stressed the importance of actually setting students up for mistakes in mathematics, especially within the first few months of the school year. By doing this she believed that a culture conducive to mistakes emerged as students understood that it is okay to arrive at incorrect answers. In effect, Nicole found that negative criticism and embarrassment was not a problem in her classroom because the students had a clear understanding that mistakes are part of the learning process and are not something to be embarrassed about. In addition, Nicole set a culture in her class that each and every student is like her child and she will protect them if anyone, either in her class or in other classrooms, attempted to upset or criticize them by speaking to those students and their teachers. She found that this created a sense of family within her classroom and her students understood that, though everyone may not get along with each other, everyone must work together in a positive manner.

In addition to removing the possibilities of negative criticism emerging within the classroom culture, Nicole and Terry both discussed their understandings of the importance that noise plays within the culture of a mathematics classroom that is conducive to student discourse. Both participants stressed that it is okay to talk and make noise, as long as it is productive noise. Nicole stated that, “Students know that my class is the talking class. The kids know that they cannot be too quiet.” In her classroom students knew that they were not allowed to be quiet because she wanted them to be in constant discussion about mathematics all the time. She, along with Victoria, also stressed the importance that students are held accountable for their talk. They both discussed the increase in engagement and discussion when students understood that they may need to respond to questions or they may need to explain their thinking.
4.3.2 Groupings

According to Terry, Victoria, and Nicole it was important that there be a mixture of small and large group discussions taking place in their mathematics classrooms. In their interviews, Nicole and Victoria simply mentioned the need for both small and large group activities that promote the use of student discourse within their classrooms. However, Terry made note of the importance that small groups have no more than 3 or 4 members working with one problem to communicate about and solve as this is more manageable for the students and there is no option for any of the students to sit back and allow others to do the work for them. In addition, both Victoria and Tim stressed the importance of groupings based on need and ability. In Tim’s classroom, groups were often created based upon need. He used similar language groups with students whom could translate for English language learners in order for them to be able to participate in the conversations. Victoria, however, often created her math groups based on ability so that she was able to work with students at their level during small group discussions. In contrast, Nicole seemed to take another approach to groupings. She allowed her grade 3 students to choose their groupings and work with their friends while simply being sure that they were working productively and had an opportunity to work with a range of different students in the classroom. Though each participant took a different approach to determine which students would work together, they each heavily relied on small group activities in order to maintain the engagement of the students and create a more student-centered mathematics program.

4.3.3 Teaching Strategies

Considering the range of grades that the three participants taught, a large majority of the teaching strategies and prompts that were used by these teachers in order to facilitate
communication amongst students are very different from one another. For this reason, this subsection is discussed by each case study.

When talking about his prior teachings in a grade 7/8 class, Terry discussed that he focused on providing open-ended mathematical problems for the students to discuss and work on, only once he had set the stage with explicit teaching. In addition, once the students completed problems either in partners or individually, they were then given the opportunity to explain and justify their answers. This was first done in small groups and then with the whole class. While doing so, in comparison to Whitenack and Yackel’s (2002) research on having students explain and justify their answers, he had his students explain the exact steps that they took and the strategies that they used to arrive at their answer so that they were constantly focusing on the process rather than the final product. Understanding the need to not embarrass or single out students, Terry stated that he always asked students to go back and check their work, even if they had the correct answer. In this way, he believed that when he needed to have students check over their work because there was a flaw in their process, they did not seem as though they were singled out because all students were asked to double check their work too. In contrast to the suggestions of Bishop (2012), Mumme and Shepherd (1990) and Small (2013) about the assessment opportunities which emerge from student discourse, due to the large class size of over 30 students and a split-grade, Terry also discussed that, though he would have loved to sit down with students as they worked on problems in order to gain a clear understanding of their thought process and knowledge, it was impossible to do so. For this reason, he stated that his assessments of student learning were solely based upon quizzes and unit tests, though, he had also stressed he needed to find a way to better match his assessments to the student discourse strategies he used in his teachings.
In Nicole’s classroom, she stated that she wanted her students to engage in discussion constantly. Therefore, each of her units began with a lot of talking and discussing real life examples. She provided the example of talking about why we study data management and providing the students with a real life situation where the school secretary needed to determine what type of cookies to buy for all the students. In this way she found that she was able to discuss with the students the ways in which what they were learning works in real life in a way that is relatable to them. Nicole stated that it was not until 3 or 4 days into the unit that the students actually started working on problems so that the foundation for mathematical discussions could be built into the units of study. Once the students engaged in group problem solving activities and portrayed their solutions in pictures, numbers and words, Nicole said that she engaged the students in a Bansho (a strategy from Japan where the students organize their solutions and findings and post them on a wall or in an area of the classroom for all students to see how they came to an answer as a group or individually) so that the strategies that the students used could be highlighted. During this time, Nicole also stated that it is important to hold students accountable and “get them to write in their math journal what strategy did you use that you noticed someone else used and what strategy did you find helpful or what do you understand?” Furthermore, she also made use of self-assessment strategies as a way to have the students’ metacognitively reflect on their working habits within their groups and hold them accountable to the actions they took during their group work. In addition to this writing piece, positively correlating to the work of Bishop (2012), Mumme and Shepherd (1990) and Small (2013), as the students were working in their small groups and engaged in discussions with classmates, Nicole discussed that she constantly took note of what the students were discussing so that she was able to informally assess the students. In this way, she found that “students are more engaged when they are working it out with their friends and they
know that the teacher is not marking them, not realizing that I hear as much as I do- so I am kind of marking them but they don’t feel judged and they can just talk with their peers.”

In Victoria’s classroom, her main focus of engaging students in math talk was to embed their learning in mathematics-based games and literature. Victoria explained that much of the math talk within her classroom was accidental. She said that through playing math games such as Yahtzee, Sparkle, and Dominoes, they were constantly engaging in math talk and they didn’t even know it. Victoria mentioned that students naturally engaged in student discourse by agreeing and disagreeing with each other and explaining and justifying their thinking and the strategies they used to come to a solution or answer. She also stated, “It’s easy because it’s not something they are actually aware of.” Another way that Victoria engaged her students in communication was through the use of literature. She stated that, “Often I embed it [math] in a story and as soon as I embed it in a story it becomes something they can visualize and then it becomes easier… and they might not even know that it’s math.” Victoria also brought up a disconnect between communication in literature and communication in mathematics. She stated, “It’s interesting because we do it all the time in language, we explain what a story is about, but we are just not used to doing it in math.” In her views, not enough communication was being facilitated in and around mathematics. Using stories such as those written by Eric Carle, Victoria discussed that her students were better able to discuss the mathematics in the stories because, when placed in literature, the math became more concrete. After reading these stories, she often engaged the students in mathematical discussions surrounding problems related to the stories and had them explain their thinking, agree or disagree with each other and debate about the solutions to the problems. In regards to the discussions that emerge, she stated that it is important to “focus on the process- how they got the answer- not on getting the correct answer so that it is open for discussion.” Though
Victoria believed that she did effectively facilitate much math talk in her classroom, like Terry, she stated that she would have liked it if there was much more time for her to sit down with the students as they were engaging in their mathematics games and discussions in order to point out and make them aware that they were in fact talking mathematically.

Though each of the three participants used different classroom strategies to promote student discourse in their classrooms, there is one strategy which emerged that was agreed upon by all three participants. In accordance with research done by Jansen (2006) and Yackel (2001) on emphasizing on students’ processes, all participants agreed with the importance of focusing on the mathematical processes and strategies that the students used to arrive at an answer rather than simply the end product. By doing this, the teachers believed that their students were able to gain a better understanding of the concepts at hand and consolidate their knowledge as they verbalized their thinking and their mathematical processes.

4.4 Teachers’ Perceptions of the Challenges Associated with Implementing Student Discourse in Today’s Mathematics Classrooms

When asked to discuss the challenges that the participants felt are inhibitors to facilitating math talk in mathematics classrooms today, Terry, Victoria, and Nicole did not fall short of discussing the many barriers which affect teachers today. These included; teachers’ perceptions and experiences with mathematics, classroom dynamics, the students themselves (including their difficulties with the subject matter, English language learners, and student personalities), external curriculum demands and assessments, and most importantly, time. Figure 1 outlines these challenges on a continuum from most teacher influenced to least teacher influenced. It is important to note, however, that, though the participants may have suggested these issues as
challenges to implementing student discourse in mathematics, not all of the challenges set forth here actually affect these particular teachers. Some are simply personal accounts from their own experiences discussing mathematical discourse with colleagues in the teaching profession.

4.4.1. Teacher Perceptions and Experiences with Mathematics

According to Terry, Victoria, and Nicole, teachers’ own perceptions and experiences, in regards to mathematics, play a fairly large role in determining the student discourse that is facilitated in their classrooms. Terry and Nicole both stated that teachers often refrain from using student discourse because they don’t like kids talking and the noise that results from the student discourse. Moving the discussion further, Nicole had put forth that, “If you don’t like math, then you might just think that it’s something to do or just something that you must teach- because at the end of the day, they have to do the task.” In her opinion, she stated, “Some teachers think that they can get further if they were just teaching it [the math] rather than implementing student discourse.” Victoria also discussed teachers’ own anxieties about math influencing their use of student discourse. According to her, some teachers say, “they don’t do math.” She stated that not being shown how to do the math or feeling uncomfortable with the idea of math discourse often detracts teachers from incorporating student discourse into their programs. In addition, she went on to state, “Teachers did not grow up with student discourse – it’s not very natural.” In Victoria
and Nicole’s opinions, if teachers had difficulties or negative feelings about mathematics programs of their pasts, these experiences carry into their future teachings. In addition, implementing student discourse in mathematics is not something that was done in the past and therefore is difficult for teachers to break out of their comfort zones of traditional methods of teaching mathematics. This notion was captured by Ezrailson et al. (2006) as they discussed that facilitating communication in mathematics can often become frightening for teachers, and by Bruce (2007) in which he wrote about teachers difficulties with facilitating math discourse in ways that they had not been exposed to in the past.

4.4.2. Classroom Dynamics

Findings in regards to challenges caused by the dynamics created within a classroom were very limiting both in the research and amongst the participants in this study, however, it is important to note that Terry discussed the difficulties which arise when teaching split grade classes with a large number of students. Terry stated, “There are two different curriculums. You can’t have one grade doing student discourse while you are trying to teach the other grade.” He went further to discuss that, because student discourse requires a certain level of noise, it is just not practical when there are two different activities, one requiring student discourse and one requiring paying attention to a lesson, going on within the same classroom especially with such a large class of over 30 students.

4.4.3. Challenges Involving the Students Themselves

4.4.3.1 Difficulties with Math Talk and Mathematics Overall

In her interview, Victoria stated that, “In language it’s more natural for them [to have discussions about stories and writing], but it’s trickier in math when you take it out of context of
a story or it’s about a specific question or skill because then they have to really think, well, how did I do that?” She went further to state that engaging in student discourse, “Requires a different set of skills. Language is more of a higher thinking skill than actually doing the math or the math concepts… the students get frustrated.” In addition, she discussed that, the amount of student discourse that takes place depends on both the group of students in the classroom each year and on the students’ capabilities with the math being taught. Although, she also stated that sometimes, the students may understand the concepts, but they simply cannot talk about them. According to Victoria, “In grade 1 students may not have the language yet, vocabulary is not there. So having them talk about math is a challenge.” Furthermore, Terry discussed that, in his classroom, there were homeschool students that were working at a different grade level in mathematics, while Victoria pointed out that there were often students with M.I.D. in her classroom whom simply could not understand what she was saying and this detracts them from engaging in student discourse.

4.4.3.2 English Language Learners

Teaching in classrooms which have a high population of English Language Learners, Terry and Victoria discussed the barriers to student discourse which may arise in their classrooms. Victoria stated that, “Students require the vocabulary and some of the [mathematical] language in order to participate in communication.” In this regard, Terry brought attention to the fact that, “the students become isolated because they don’t have the language. The students end up sitting by themselves and not communicating with others.”
4.4.3 Students’ Personalities

In the experiences of Terry and Nicole, the students’ personalities can often create a challenge to the student discourse which could be taking place within their classrooms. According to Terry, some students have a lack of confidence in their own abilities to do math, or they may feel discouraged from participating if there is a possibility that their answers could be wrong. In Nicole’s experiences, however, she found that there are simply some students that don’t want to talk. She specified that, “Some students like completing their work on their own, and, if they are put in a math centre for a collaborative activity, they may shut down. But if they were left on their own to do the activity they would be able to do it on their own.”

4.4.4 External Demands of Curriculum and Assessments

Terry and Nicole both stressed the challenges which are associated with external forces including meeting Ontario curriculum expectations and engaging students in assessments. In Nicole’s experiences discussing student discourse during professional development sessions and cluster meetings, she had found that, “Some teachers say that ‘I need to know what they know, not what their friends know’.” She then went on to state, “Individual assessment is difficult with student discourse.” However, from her perspective, “students find it difficult to do tests where they cannot talk.” During Terry’s interview, though he stressed that, “Pencil-and-paper tests do not assess based on student discourse,” and, “Students rely on the student discourse and find it hard to complete paper-and-pencil tests that do not allow for communication,” he also discussed that, due to the overabundance of curriculum expectations that he faced teaching in a large, split-grade class, most often he resorted to traditional paper-and-pencil tests to assess the students’ knowledge and understanding. In this way he was able to assess all of the students more
efficiently. Furthermore, Nicole conferred that there is simply, “Too much to get through, especially in grades 3 and 6 with EQAO”. In this regard, she stated that, “The challenge for students becomes even more apparent during EQAO testing where the students are unable to talk or ask any questions.” According to these two teachers, they understood the need to match assessment to their teaching strategies, however, there are simply too many external factors that inhibited their abilities to do so and, therefore, caused them to resort to formal testing because they had to prepare their students for future standardized tests.

4.4.5 Time

The issue of not having enough time was noted by all three participants to be the most significant impediment for implementing talk activities. It should be noted that this was the only issue that was mentioned by all three teachers. Terry explicitly stated that, “Time is the biggest challenge for me.” In line with Bruce’s (2007) discussion about the lack of time to facilitate student discourse in mathematics, to Terry and Victoria, with such a lack of time, it is impossible to have time to sit down with students to discuss mathematics activities and their mathematical thinking on a more individual level while also attempting to provide assistance to students whom request help or may be struggling with engaging in mathematical communication during group activities. Victoria stressed that in grade 1, “There is a lack of time to sit down with small groups during activity time. More time is needed to sit down with students and point out that they are in fact communicating mathematics as they are playing games.” While in Terry’s opinion, it took time to orally assess students and mark them while circulating, it took time for kids to talk, it took time to do the three part lesson, it took time to let the kids work in a group and discuss, and it took time to debrief the students learning. Terry believed that, “Rushing student discourse is not effective”, however, effectively facilitating student discourse simply took time which was not
always available for conducting math discussions on a daily basis. On this note, Nicole also mentioned that because she took the first 3 or 4 classes at the beginning of each unit to properly set the stage for learning, (which is often almost a third of other teachers’ units), she felt as though she was, “Crunched for time trying to get through the curriculum and, especially in grades 3 and 6, preparing for EQAO testing.” In his work on student interactions in mathematics, Bruce (2007) also pointed out this lack of time available to teachers to facilitate student discourse while also struggling with too many curricular demands. In this regard, all three participants had discussed that there was simply not enough time for all teachers to effectively engage students in mathematical discourse and also be able to provide the necessary feedback on learning on a daily basis.

4.5 Practical Strategies and Suggestions for Current and Future Teachers of Mathematics

4.5.1 Teaching Strategies

When asked about some practical strategies and suggestions that teachers can use in their mathematics programs, the participants in this study provided a comprehensive list that teachers, both new and experienced, can use in order to teach for understanding. Not all of the strategies could be displayed, therefore, only the most significant strategies which emerged are discussed. All strategies and suggestions provided have been tried, tested, and greatly used by the participants and have been set forth as manageable strategies and suggestions that teachers, while also facing the many pressures and challenges to implementing student discourse, can use in order to effectively facilitate communication in their mathematics classrooms and, in turn, teach for understanding.
Through the interviews with Terry, Victoria, and Nicole, many strategies, though very different, emerged from their responses in regards to their own teaching strategies and strategies which they felt teachers should use in their own mathematics classrooms today. Across all three interviews each participant stressed the importance of having teachers focus on the strategies students used as a way to increase student discourse in and around mathematics. Victoria stated, “Be open to incorrect answers- focus on the process (how they got the answer) not on getting the correct answer, so that it’s open for discussion,” while Nicole suggested, “Focus on the learning process and talk about the strategies rather than the end result… focus on where the students went right and where they started to go in different directions.” With this, Nicole and Terry both stated that it is also very important for students to be given open-ended problems. In line with the strategies proposed by Bruce (2007), Nicole explained that teachers should start off with open-ended questions and then move to more specific questions. In her opinion, this would enable teachers to notice if students were struggling on a particular area, question, or problem so that they could still assist them. Additionally, Terry stressed that, “Often in math class it’s close-ended because there’s only one answer. So as teachers, we would come up with a problem that has one answer.” In this regard, in order to get students talk more about the math, Terry suggested to teachers,

Let them make up their own problem… say, okay, ‘As a group I want you to make up a word problem that is open ended because there is no one right answer… and then solve the problem and be able to explain to the rest of the class how they solved the problem that they made up using the very specific steps.’ So it’s very open-ended and this really tests them on a higher level because they have to be able to generate in blooms taxonomy synthesis; which is at the very top. So they can
synthesize and make up the problem and then solve and explain to others how they solved the problem. That to me show’s that they have understanding and that fully increases student discourse. Plus it increases engagement, too, because they can make the problem about anything that they like.

In Terry and Nicole’s opinions, these open ended questions elicit far more mathematical discourse than close ended questions where there is simply a right or wrong answer. In this way, in her research, Olive Chapman (2009) stated, “…this view of discourse takes account of students’ personal experiences, thoughts, and feelings. It capitalizes on and values students’ contributions to their learning… Thus, through it, students can come to realize that their ideas are valued and, as a result, have more authority over their learning and engage in more voluntary participation” (p. 334). Additionally, in line with research conducted by Whitenack & Yackel (2002), Small (2013), and Bruce (2007), Victoria suggested that teachers be open to incorrect answers and provide opportunities for students to engage in debates and agree or disagree with their peers about questions which are open for discussion.

During their interviews, as ways to prepare students to engage in student discourse, Nicole suggested that teachers apply math to the students’ everyday lives. She said, “In terms of communication, if you really focus... on the real world application, I think that just leads to easy conversation.” In contrast, however, Victoria suggested that teachers use visualization as a way to prepare students to engage in student discourse and have something in their minds to discuss. She stated, “We do a lot of visualization. What does it look like? What does is sound like? The more senses you have involved, the better.” In Victoria’s experiences, when students visualized the math they more easily had something to contribute to conversations.
The participants were in consensus that it was paramount to keep the discourse student-centered so that the focus remained on the students discussing the mathematics with each other rather than with the teachers. Terry stated, “Keep the math student-centered more than teacher-centered.” While Victoria stressed the importance to teachers that students be provided with multiple opportunities to have choice in engaging in mathematical games and activities such as Yahtzee, Dominoes, Sparkle, and iPad applications because of the communication which is elicited from these games. She stated,

When the students engage in math activities and games in the classroom, student discourse becomes much more peer-to-peer…Well, it’s interesting. When you really think about it, we have so much time when they do math activities and they choose. So they have a lot of choice and choice leads to motivation to do things. In fact, when I think about how much time they spend doing those activities, it is far more peer-to-peer because they are working together, not talking to me.

By keeping the communication much more peer-to-peer, the participants felt that teachers will observe much greater engagement and motivation to learn on the part of the students.

While students are working in their small groups, in accordance with Bishop (2012), Small (2013), and Williams & Casa (2012), Nicole and Victoria suggested that it is also important for teachers to capitalize on opportunities to assess the students. Nicole stated that teachers should pull students aside to talk about the math while they are working, while Victoria suggested that teachers must, “Take the time to sit down with small groups of students while they are playing math activities to point out that they are in fact communicating mathematically.” In addition to this assessment piece, Nicole suggested that, in accordance with Williams & Casa (2012), it is important to allow students to write about the math and the strategies they used. In this way, she
said that this gives all students, even the students whom choose to stay quiet, an opportunity to communicate their thinking in writing and provides a more inclusive environment for all students.

### 4.5.2 Integrating Strategies from Other Subject Areas

According to the three participants, incorporating strategies which are commonly used in other subject areas is a very simple way to get students to talk about the math. In Nicole’s view, she stated that, just as accountable talk is used in language, teachers should be using accountable talk in mathematics so that the students know that they could be called upon at any moment in order to discuss mathematics. In this way the students know that they must be attentive and engaged in their learning. Victoria also agreed that the strategies used in language arts are easily transferrable to the mathematics subject area. According to Victoria, teachers should embed mathematical concepts in stories and use stories which already have mathematical concepts built into the story line, such as those written by author, Eric Carle and Marilyn Burns, as much as possible so as to provide the students with opportunities to visualize the mathematics. She also stated that, when engaging with the students in small groups, teachers can use a guided reading format by highlighting mathematical concepts, in place of reading strategies, as the students engage in the activities provided. In Victoria’s many years of experience teaching mathematics in the primary grades, she had also made use of the incorrect/correct model, drawn from literacy programs, to demonstrate to the student’s appropriate behaviours. In Terry’s opinion, however, coming from a math and science background, he said that, in order to get students to begin discussing their strategies, teachers should, “Have the students solve their problems similar to writing a procedural science lab report.” With this strategy, the students are forced to provide a step-by-step explanation of the strategies they used to solve the math problems.
4.5.3 Math Prompts

In her interview, Victoria stressed an important piece of advice to teachers by stating, “Don’t be afraid of math. Start off with a couple of prompts and see how it goes, see what works, and what doesn’t work.” According to the participants in this study, math prompts were referred to as ways for teachers to elicit more comprehensive responses from students through the use of sentence starters and/or simple questions. In order to elicit quality student discourse in a mathematics program, the participants suggested many math prompts that teachers can easily use, which are very similar across the three grades that these teachers happen to teach. The only real differences in the math prompts suggested by the three teachers were in the language that should be used with the students at the different grade levels. Terry, Victoria, and Nicole all stressed that the underlying goal of student discourse was to have the students explain their thinking. In this regard, the most emergent math prompt that was suggested was, “Explain your thinking.” In addition, all three teachers suggested that mathematics teachers should focus on the strategies that the students used to arrive at a solution rather than the resulting answer. This lead to their next suggested prompt which involved students explaining the strategies that they used throughout their problem solving activities. According to Terry, teachers should ask the students to, “Tell me the steps you took to get the answer you got.” He also went further to suggest that teachers ask, “What information from the word problem did you use? When did you use it? How did you use it to come up with your final answer?” Consistent with these prompts, Victoria suggested the use of math prompts including, “What clues do you see? Why do you think that’s there? What are the clues that made you think that inference?” Additionally, Nicole suggested math prompts such as, “What strategy did you find helpful? What strategy did you use that you noticed someone else used? What do you understand? Pictures, numbers and words, how can they help you?” Furthermore, Nicole
suggested to look to the Ontario mathematics curriculum document. She said, “Use the teacher prompts that are provided in the curriculum documents- they are a good starting point for talking pieces.”

In the opinions of Victoria and Nicole, who teach grades 1 and 3, they discussed that, often times, students require more sentence-starting prompts if they are to engage in mathematical discussions. According to Victoria, helpful sentence starters included, “I know the answer because…, I know this because…, I figured this out by…, I heard you say… (which is also used in language where the students will then tell back what they heard their peers say),” while Nicole suggested prompts such as, “I agree with you because…, I disagree with you because…” Both Victoria and Nicole suggested that these prompts be used often so that using they become second nature to the students when they are engaging in math talk.

Terry and Nicole also both suggested that sometimes the students may require prompting in order to check over their work or see if there are any other strategies that they can use to come to a solution. Terry stressed that it is important for teachers to constantly ask all students, even if they are on the correct track, “Are you sure?” and prompt the students by saying, “Let’s go back to this step…, and “Double check to make sure you did this part correctly.” In Nicole’s opinion, sometimes it was necessary to give the students hints when they were struggling or when they seem to be on the wrong track. She stated, for example, “Remember T-charts are a good tool. How do you think they can help you?” Furthermore, Nicole found that, in order to get students into the habits of double checking their own work to see if there was anything missing or incorrect, it was helpful to provide students with an incorrect example of a pictures, numbers, and words solution to a problem and ask the students, “What was done right? Are they on the right track? Where did they go wrong?”
ENGAGING STUDENTS IN MATHEMATICAL COMMUNICATION

Though not suggested by all participants, Victoria also stressed that, most often her grade 1 students required visualization prompts such as, “Close your eyes and picture this…, What do you see? Think about it. How are you going to do this? What does it look like? What does it sound like?” Victoria discussed that grade 1 students often cannot visualize math in their heads, therefore it is important for teachers to assist the students by using some of these suggested prompts. In this way, she suggested that students will be able to gain a better understanding of what they are discussing as they visualize a more concrete way of looking at the math.

4.5.4 Group Activities

Throughout their interviews, Terry, Victoria and Nicole each provided strategies in regards to the many ways they facilitated group activities in their mathematics classrooms in ways which supported student discourse and, “Keep the math more student centered rather than teacher centered” (Terry). However, each participant suggested very different strategies according to the diverse grades which they teach (or have taught in the past). For Terry, group activities which worked for him in his past grade 7/8 classrooms included small group problem solving where students were divided into predetermined groups, generally based upon their language and learning needs, and were provided with a math problem to solve as a group. He also suggested that another good strategy to use with the grade 7/8 students was to provide them the opportunities to engage in group homework checks. With this activity, prior to being given the answers to their homework in a large group, they were given the chance to engage in mathematical communication about the problems and explain and justify how they came to those answers whenever there was a discrepancy between the students’ solutions in their small groups. In this way, Terry found that he was able to then determine the problems which the students in the class had more difficulties
on and followed up by posing those problems to the whole class as a way to collaboratively take up the homework.

Similar to Terry’s suggestion of using a combination of small and large group activities, Nicole suggested that the group strategies which she believed teachers should incorporate in their classrooms were also small group problem solving activities and whole group Bansho activities. With respect to the small groups, Nicole suggested that students should be able to constantly talk about the math, even if the work was not meant to be completed in groups. According to Nicole, “The light bulb doesn’t really click until they get the chance to talk about it…” Nicole found that, for some students in the class whom needed to verbalize their understandings and listen to the explanations and justifications of others in order to fully understand the math, it was detrimental to the success of these students that they were given the opportunities to engage in mathematical discussions with their peers. She said that this becomes apparent, too, when teachers facilitate whole group activities such as a Bansho, in their classrooms and the students are able to see and discuss the different strategies that other students used to solve the same problem.

In line with Terry’s suggestion, however, Victoria stressed the importance that teachers should facilitate, for the most part, small group activities in which the students are grouped according to their levels of abilities similar to guided readings groups. In this way, she said, “Students will then have more, and richer, discussions that are more focused on their needs.” Similarly, she went on to state that by engaging students in these small group activities, teachers will be able to provide much “more individual feedback” as they circulate while the students are engaging in activities and games. In addition she stressed that math games and activities, such as Yahtzee, Sparkle, Dominoes, and math iPad applications, should be available to students to play in small groups and/or partners so that, “Student discourse becomes more peer-to-peer.” In this
way, she also suggested that teachers, “point out to the students that they are actually communicating mathematically during math activity time and all other times” so that they can see the math in everything they do and everyday situations and understand the importance of engaging in mathematics. With respect to large/whole group activities, however, Victoria suggested that, unless there is going to be a great amount of interacting and the students are going to be engaged in think-pair-share/turn and talk discussions throughout (which, in essence, is small group discussion), whole group activities should be kept to a minimum. She said, “It is slow when it’s done in a large group…You can only keep engagement of grade 1’s for 10 to 15 minutes until you’ve lost them if there’s no engagement between them.” In Victoria’s opinion, teachers should implement small group games and activities much more often than large group activities in mathematics.

4.5.5 Classroom Dynamics

Across all three participants, it was stressed that a fundamental aspect of classroom dynamics that must be present in order for mathematical communication to take place is to set up a culture that incorrect answers are okay but it is not okay to negatively criticize peers at any point. Victoria said that it is important to “Prepare students to always respect each other”, while Terry commented that the students should listen to everybody’s opinions and understand that there should be, “No put downs, no disrespect… but it is okay to disagree as long as you disagree respectfully.” Terry also stated that it is very important for teachers to also not embarrass or discourage students from engaging in student discourse by singling them out. Moving this idea forward, Nicole stressed that teachers should create a culture where the students understand that it is okay to take risks, take chances, it is certainly okay to make mistakes, and it is okay if the
students do not like math, but they must always be respectful of one another. In addition she suggested that teachers should always promote a sense of family within their classrooms so that the students know that they can all trust each other and feel safe within the classroom in order to take risks and chances without the possibilities of being ridiculed. Another interesting suggestion set forth by Victoria was to create a culture where the students may not say ‘no’ to one another or huff when someone asks to work with them. She mentioned that the, “Answer is always ‘yes’ when someone chooses to work with another student. They are not allowed to say ‘no’ or make faces or huff.” In addition she stated that it is very important, especially at such a young age, that students “practice appropriate behaviours and what they sound like and look like.” Victoria stressed the importance of having students, “Practice the right way and wrong way to increase muscle memory.”

Along with creating a safe environment for students to work in, Terry, Nicole, and Victoria all agreed that another important suggestion for teachers was to create a culture of students engaging in mathematical communication with other students more than engaging in discussions with teachers. Nicole constantly told her students to, “Talk about it, talk about it.” She found that it is more important for students to talk to peers more than to the teacher. In Terry’s classroom he said that, “Peers talk to peers 2/3 of the time and peers talk to the teacher 1/3 of the time, including times when students are explaining their answers to the class.” In doing so, Terry also suggested that it is important that teachers, “Don’t be afraid of noise! Allow students to talk!” Nicole also stated that it is important for teachers to not be uptight because students do not always learn when the teachers tell them exactly what to do. She explained further that teachers should allow the students’ to talk about the math and talk about the issues they are having with finding solutions so that they are more engaged because they get to talk about what they want to talk about around the
math problem rather than what the teacher tells them they should do or focus on. In this regard, Terry drew a parallel between teachers and students, “Don’t teachers talk to each other about how to teach a lesson? Well students need to talk to each other about how they do a math problem, and when you talk there will be noise.” Furthermore he stated that, “A lot of teachers worry that if there is too much student talk, too much group activities, that they lose control of the classroom, and that it would become too noisy. My advice to them is to say, you know what, let it go. If it gets too noisy then just bring it down.” He also added, “A silent classroom where the teacher just talks is not necessarily the productive classroom. Trust your students and understand that it is okay for there to be noise in a math classroom because they are discussing.”

### 4.5.6 Professional Development

When asked about the professional development which they felt teachers should have in order to become effective facilitators of mathematics discourse a few suggestions were provided. According to both Victoria and Nicole, teachers should certainly participate in mathematics PD sessions which take place within the schools such as school in-services and cluster meetings. Both Victoria and Nicole also suggested the importance of workshops based on teaching and facilitating math, however, Nicole noted that these workshops should be attended by teachers, “only if administrators are going to hold teachers accountable to what they are learning at the workshops, otherwise the workshops will not be very effective.”

Though not specific to mathematics, when asked the question about professional development, because he stressed in his interview that teachers should not be afraid of noise and that teachers need to simply manage the noise effectively, Terry suggested that teachers should
attend professional development sessions focused on providing classroom management strategies on how to keep kids focused during group work. He stated,

I would say classroom management. Because, to be honest, a lot of teachers are worried about how to manage the noise levels and all of that stuff if there is so much student talk. Because, if you know that if you let go- if the teacher is no longer the centre of attention- and you let the students separate into group work, there will always be some students and some groups that will not stay focused. They’ll say, “Ohh, we don’t need to listen right now because the teacher will be circulating and the teacher can’t monitor every group at the same time.” As the teacher circulates there will be groups that goof off. And maybe teaching teachers some classroom strategies on how to keep kids focused during group work will be very helpful, I think, because you don’t want to be the teacher that is super strict where the students are afraid of you because then they will shut down in math class. But you also don’t want to be this super lenient teacher where you let the kids do whatever they want.

According to Terry, professional development on classroom management is important in helping teachers to find a balance between becoming too strict and too lenient.

In addition to these suggestions, Victoria put forth a number of other professional development opportunities that teachers may engage in on their own. In her opinion, teachers should attend conferences, such as Reading for the Love of It, where they often have mathematics based sessions. In addition she stated that teachers should engage in professional reading, including books from author Marilyn Burns whom she described as “one of those math guru’s,” online research and reading of math related websites, blogs and articles, and watching YouTube videos related to student discourse in mathematics classrooms.
Chapter 5: DISCUSSION

The following chapter discusses the purpose of this study proposed in chapter 1, the links to the literature which emerged from the findings, and recommendations and implications for future studies and classroom practices. This chapter is divided into 11 sub-categories including an overview, correlations to the literature review, a discussion and evaluation of the findings, implications for my future as a teacher and a researcher, implications for the broader educational community, recommendations for future practices, limitations of the study, questions which have emerged from this study, next steps for further research, and a brief conclusion of this study.

5.1 Overview

The purpose of this study, as outlined in chapter 1, was to raise awareness of the disconnect which seems to continuously emerge between teachers’ understandings of the benefits of student discourse and their actual implementation of student discourse strategies into their teaching practices. In addition, as outlined in the main research questions and sub-questions, the goal of this study was to bring light to some of the challenges which inhibit teachers from facilitating mathematics communication in their classrooms and to determine practical strategies which current mathematics teachers are, in fact, using in their mathematics classrooms so as to facilitate student discourse and increase student understandings of mathematical concepts. The findings outlined in Chapter 4 of this research paper determined that teachers have a clear understanding of the benefits which emerge from facilitating communication in their mathematics classroom and they are in fact facilitating a great deal of student discourse strategies in their classrooms. However, it was found that the amount of student discourse strategies which are actually used by teachers within mathematics classrooms depends heavily upon teachers’ own personalities and experiences with mathematics, classroom dynamics both in regards to the abilities and
personalities of the student population and the learning environment, external curriculum demands and assessments, and the time that is available to effectively facilitate the often long processes of student discourse.

5.2 Correlation between Findings and the Literature Review

In accordance with Chapter 2, there is a strong correlation between the research discussed in the literature review and the findings which emerged through the interviews with the three participants of this study. Mumme and Shepherd’s (1990) findings of the benefits of using communication in the mathematics subject area, are reflected in Nicole, Terry and Victoria’s view that math talk plays a key role in facilitating students’ understandings of mathematical concepts and developing shared understandings. In addition, the participants discussed the importance of explaining and justifying their thinking through student discourse which is positively correlated with Whitenack and Yackel’s (2002) understandings that,

Students reap many benefits from reasoning mathematically. They often develop or refine their ideas as they explain and justify their thinking. More generally, by allowing them to explain and justify their ideas, teachers help students develop mathematical dispositions. (p. 527)

It became clear in their interviews that the participants clearly understood the impact that student discourse has on students’ individual mathematical understandings and their development of shared understandings. In addition, the participants seemed to understand that students require opportunities to engage in rich peer-to-peer and student-to-teacher verbal communication so the conversations may continue and teachable moments may be capitalized on within the learning community.
Furthermore, the findings correlate positively with the research in regards to using student discourse as a way to capitalize upon more authentic forms of assessing students in mathematics. Though Terry and Victoria suggested that they had not had too many opportunities to sit down with their students in order to point out their mathematical thinking and gain a clear understanding of their mathematical knowledge, they, along with Nicole, discussed their understandings of the opportunities for assessment which arise when students engage in mathematics discussions. This correlates positively with research conducted by Small (2013), Williams and Casa (2012), and Bishop (2012).

Most of the teachers did not concur with Bruce (2007) that some of their students felt that through talking about mathematics, other students might “steal” their ideas. The teachers stressed the importance of establishing positive classroom environments where students felt comfortable to share their thoughts and understandings. In addition, suggestions in the literature by Ross, Bruce, and Hogaboam-Gray (2006) and Bruce (2007) that co-curricular activities, yard duties, and home-life responsibilities provided challenges for teachers by cutting into their preparation time for discourse activities, did not play a role in the participants’ discussions about the challenges they encountered when implementing talk activities. Emerging from the findings, it is simply the personalities and perceptions of teachers’ and other challenges, such as time and curricular demands, which inhibit their abilities to implement student discourse in their mathematics classrooms. Additionally, there were other challenges mentioned in the interviews that were not noted in the literature. These included challenges involving split-grade classrooms, the students themselves, and standardized tests. According to the participants, these challenges played a large part in the effective implementation of math talk in their programs.
The strategies set forth by Bishop (2012), Bruce (2007), Small (2013), and Yackel (2002) which include making use of open-ended questions, providing opportunities for students to justify their solutions, question and engage in debates with peers, and providing guidelines for math talk, were also mentioned by the participants as excellent strategies for implementing student discourse. However, Terry, Victoria and Nicole also offered additional suggestions for implementing mathematical discourse. The following list provides a brief overview of the suggestions provided:

- keep the discourse more student-centred with more peer-to-peer interactions
- use strategies from other subject areas including language and science
- focus on the strategies which students use to come to solutions
- be open to incorrect answers
- begin with open-ended questions and then move into more specific questions
- allow students to make up their own problems
- relate the math to the students’ everyday lives
- have the students visualize the math
- assess students as they are engaging in student discourse and small group math activities
- incorporate many opportunities for students to play math games
- implement math prompts which elicit students to explain their thinking and remain on task
- group students according to their abilities, or allow students to choose their groupings
- engage students in Bansho activities to talk about the strategies used by the students
- create positive classroom environments which allow the students to feel like a family
- have the students talk about everything
- allow students to make noise
- engage in professional development sessions regarding math talk and classroom management
5.3 Discussion of the Findings

In accordance with the findings in this chapter, the amount of student discourse that takes place within a classroom can be summarized into the mathematics equation outlined in Figure 2. The findings determined that the main factors influencing the amount of student discourse strategies used in mathematics classrooms today include teachers’ perceptions and the challenges which face the teachers on a daily basis.

![Equation Diagram]

*Figure 2*

There are 3 possible situations which can emerge from this equation outlining the findings of this study. The first situation states that, when the teachers’ perceptions of the benefits of student discourse outweigh the challenges to student discourse, teachers will be able to employ more strategies conducive to mathematical talk in their classrooms. However, both the second and the third situations state that when the teachers’ perceptions of the benefits of student discourse are equal to or less than the perceived challenges to implementing student discourse, a limited amount of discourse strategies will be employed. When a great deal of challenges persist, no matter their ideas about the importance of communication in mathematics, teachers’ will become reluctant to employ strategies which promote the use of math talk in their classrooms. In a positive light, however, when looking back at the ways in which the three participants of this study facilitated
student discourse in their own classrooms, all three of them seem to fall under the first situation in which the benefits outweigh the challenges. In this sense, they are better able and willing to employ a great deal of student discourse strategies and math talk in their mathematics classrooms.

As discussed in the findings, it should be noted that the impact the challenges have on the implementation of mathematics discourse correlates directly to the amount of influence teachers have on these challenges. Challenges on which teachers have limited influence such as curriculum demands, standardized tests, time, and the student makeup of their class can have a great impact. Though teachers are able to influence their abilities and perceptions of the benefits of student discourse in mathematics and the classroom dynamics which they maintain in their own classrooms, if the challenges which teachers have the least amount of influence on outweigh those influenced by teachers, this will cause them to employ more traditional methods of teaching mathematics.

In this regard, considering that the findings and the literature consulted in this study demonstrated that there is a great understanding among teachers that discussions in and about mathematics are important to the success of students and to their consolidated understandings of mathematical concepts, it is clear that efforts must be taken to reduce the effects of the challenges - those over which teachers have the least influence which can inhibit the infusion of student discourse. In this sense, it is evident that greater support for verbal communication in mathematics must be provided not only by teachers themselves, but also administrators, curriculum developers, and assessment developers in order for students to receive greater opportunities to succeed in mathematics and gain greater confidence in themselves as mathematicians.
5.4 Evaluation of the Findings Confirming or Denying the Expected Results of this Study

Through the interviews conducted with Terry, Victoria, and Nicole, the findings confirmed that there is a disconnect between the importance placed on using student discourse in mathematics and the benefits it elicits, and teachers’ abilities to implement mathematics discourse due to the many challenges they face. Though teachers are, in fact, able to employ strategies in their classrooms which support student discourse, they are often finding it very difficult to facilitate quality mathematics programs that are based solely on student discourse practices. This becomes ever more apparent when students are placed in split grade classrooms with large class sizes, when students are expected to perform highly on EQAO (Education Quality and Accountability Office) testing which is a paper-and-pencil assessment meant to be conducted in a silent manner, and when teachers are expected to assess students based on an over-abundance of curriculum expectations, in all subject areas, in such a short amount of time.

Terry, Victoria, and Nicole suggested a number of practical suggestions and strategies for teachers, which were laid out in Chapter 4, that they are currently using in their own classrooms in order to elicit a great deal of mathematical communication between peers, and in some cases, between students and teachers. As mentioned above, these strategies, which emerged from the data, have confirmed suggestions that teachers implement many strategies and ideas which they use to overcome some of the challenges they face. However, the findings also suggested that if challenges caused by classroom sizes, split grade classrooms, and an overabundance of curricular and external assessments, are not reduced and they become too large so as to outweigh teachers’ understandings of the benefits of communication in mathematics, the facilitation of student discourse in today’s classrooms will immensely decrease.
5.5 Implications for my Future Teachings

As a result of the research conducted in this study, I have gained a much greater understanding of the importance that student discourse and communication in mathematics plays on students’ enduring understandings of mathematical concepts. Through this research I have also found comfort and ease in knowing that there are many teachers in education whom are effectively facilitating student discourse in their classrooms and that there are many effective and practical strategies which I can use in my own classrooms so as to provide my students with greater opportunities to learn, succeed, and be able to see themselves as mathematicians, which in effect will boost their confidence and their willingness to learn and participate in mathematics.

Now that I have gained a clear understanding of the challenges which play a large part in inhibiting teachers from facilitating student discourse in their mathematics classrooms, by simply understanding these challenges I will be able to use the strategies mentioned in this study in my own practices. Furthermore, I have come to understand the great importance of engaging in professional development as a teacher and researcher to become further educated on how I will be able to better meet the needs of my students in mathematics and overcome the challenges I may face.

As a teacher, I plan to make great use of the strategies and suggestions set forth in this study. By doing so I will make use of open-ended questions to elicit discussions, hold students accountable to their learning, use literature and games to facilitate learning and discussions, and create a sense of family within my classroom. In this way I will be able to create positive learning environments for my students to feel comfortable to learn and be able to engage in mathematics in a more interesting way through explaining and justifying their mathematical thinking.
Taking into account Victoria’s statement, “Don’t be afraid of math. Start off with a couple of prompts and see how it goes, see what works, and what doesn’t work,” and Terry and Nicole’s suggestions of not being afraid of noise and letting the students engage in constant communication in the classroom, these suggestions will be important in my own practice as I try new ways of engaging students in math talk. By using the prompts, strategies and suggestions provided in this study and those provided in many other studies available to math teachers I will be able to experiment and simply find what works for me and, most importantly, what works for the changing dynamics of the students in my classrooms each year. In this way I will be able to provide opportunities for students to practice mathematical talk in ways that are meaningful for the students and, in turn, build their understandings of mathematical content so that they are able to achieve higher success rates.

5.6 Implications for the Broader Education Community

This study highlighted the benefits and challenges that three educators identify with implementing mathematical discourse. These findings can assist school districts, policy and curriculum developers in examining current practices that may discourage the use of mathematical discourse and make changes. In addition, this study found that teachers’ past experiences with mathematics play a large part on whether or not they will implement student discourse into their practices. Thus, mathematics education must become much more relevant and engaging for students. If we are to foster quality teachers and mathematical thinkers who may be required to teach mathematics in an engaging way for students in the future, students must be provided with mathematics experiences which include opportunities to explain and justify their thinking. Additionally, teachers need to be willing to employ assessment strategies which are aligned with
the teaching strategies used within their programs so that students are provided with greater opportunities to succeed and build confidence as mathematicians.

Furthermore, another implication for the broader educational community emerging from this research is the need for the implementation of student discourse teaching strategies beginning as early as possible in the primary grades. In this way, by the time students are entering into junior and intermediate grade levels they will already be used to engaging in mathematical talk in and around mathematical concepts. For this to take place, however, all teachers, beginning in the primary grades must be supportive of and willing to use student discourse strategies in their classrooms as a way to build students conceptual knowledge of mathematics. Accordingly, the teaching strategies that the teachers used in this study may be extremely helpful for other educators, including school district consultants and administration, who are interested in implementing student discourse in mathematics programs. The teachers in this study found that these strategies enabled them to implement mathematical discourse in a variety of contexts and therefore may prove to be helpful to all other educators.

Finally, this research has implications for professional development opportunities for teachers. The participants of this study suggested that increased professional development be provided for teachers, which are supported by the school administration, in the areas of classroom management and implementing student discourse into classrooms through workshops, in-services and cluster meetings. According to Nicole, administration must be supportive of this professional development so that they will hold teachers accountable to implementing student discourse practices into their teachings. In this regard, teachers in the broader educational community must be willing to engage in greater professional development on the topic of mathematics discourse so that they are able to better support the needs of students in todays’ mathematics classrooms.
5.7 Recommendations

Resulting from this study, a few recommendations have emerged. First and foremost, it is recommended that teachers continue to support student discourse in their classrooms so as to provide more opportunities for students to become engaged in mathematics, enjoy their learning experiences, and gain enduring understandings of mathematical concepts. Secondly, it is recommended that school administrators and school boards continue to support the use of communication in mathematics and hold teachers accountable to engaging in professional development and implementing student discourse strategies into their mathematics programs. Finally, considering the continued popularity and use of student discourse in mathematics classrooms today, teachers need to improve assessment strategies to align with communication-based activities. Furthermore, it is recommended that standardized testing, such as EQAO, be revamped so as to be realigned with student discourse teaching strategies used in mathematics. In this way students will be provided with greater opportunities for their true understandings to emerge during authentic assessments and in turn, increase their opportunities for success. In addition, providing opportunities for educators to share/discuss ideas and strategies related to their journey of implementing mathematical discourse may assist educators in becoming more confident in developing a mathematics program that infuses student discourse.

5.8 Limitations of the Study

Since this research consists of three individual interviews with three teachers who teach different grades, the findings may not be generalized to every teacher in every school. The study also provides rich details about the teachers and their thoughts and experiences and the findings which emerged may provide ideas and insights that could assist others as they explore issues
related to mathematical discourse. There may be aspects of this study that readers may be able to generalize to their own contexts, however, the onus is on the reader to assess which aspects of this study is relevant to their own educational context.

In addition, seeing as a profile of the students in each of the participants’ classrooms was not taken prior to the selection of Terry, Victoria, and Nicole, we cannot be sure that these teachers are experiencing the same amount of difficulties with respect to students’ abilities within their classrooms. Therefore, within the participants’ classrooms, there may have been very different students with varying abilities, which, in turn, may cause the teachers to have differing challenges and experiences with student discourse in their classrooms. Also, due to the fact that their classrooms had differing population counts and the grade levels ranged between grade 1 and grade 8, Terry Victoria, and Nicole would have had very different experiences and challenges with facilitating student discourse in their classrooms based on the age of the students and the number of students within each classroom.

5.9 Further Questions

From this study, a few questions have emerged including: how many students are pulled out of the participants mathematics classrooms in order to attend self-contained classrooms? How supportive is the administration of student discourse in the schools which the participants work in? What kinds of administrative support is beneficial for the implementation of student discourse? With respect to the participants' choices of groupings, does the ability for students to choose their groups change the amount of student discourse that takes place within the mathematics classroom?
5.10 Next Steps for Further Research

Emerging from the findings, further studies will be needed on matching assessments to the teaching strategies used in the classroom which facilitate student discourse. In most regards, assessments which rely solely on paper-and-pencil testing are no longer sufficient for assessing students’ true mathematical understandings while student discourse strategies are used by teachers in their practices.

In addition, it would prove beneficial to teachers of split-grade classrooms for researchers to engage in further studies regarding the effective facilitation of math talk in classrooms where the curriculum for both grades is quite different. It may be of importance to look further into effective ways to facilitate student discourse in split grade classrooms considering Terry discussed that there are simply not enough resources in circulation in support of split-grade classrooms.

5.11 Conclusion

Throughout this study, it was determined that the three participants seem to be using a great deal of student discourse in their mathematics classrooms. According to the teachers, the frequency of the implementation of student discourse is heavily dependent upon the teachers’ own perceptions of the benefits that student discourse provides to student learning minus the challenges teachers face when attempting to facilitate math talk in their classrooms. In this regard, the claim that there is a disconnect between teachers’ understandings of the importance that student discourse has on student learning and teachers’ actual implementation of student discourse in their mathematics programs, have been confirmed. However, the findings in this study challenge the kinds of issues that prevent teachers from implementing mathematical discourse. This study
identified a very different list of challenges, such as teachers’ experiences with mathematics, classroom dynamics and the students themselves.

Though there are many challenges which have emerged through this study, it is important for the future of student discourse in mathematics classrooms that teachers, schools, school boards, and the Education Quality and Accountability Office work towards eliminating these challenges by aligning practices with strategies that are more conducive to engaging students in mathematical discourse and authentic assessment opportunities. It is only when this takes place that students will have greater opportunities to succeed and will choose to further engage in mathematics as they grow throughout their education.
REFERENCES


Appendix A: Letter of Consent for Interviews

Letter of Consent for Interview

Date: ____________________

Dear ________________

I am a graduate student at OISE, University of Toronto, and am currently enrolled as a Master of Teaching candidate. I am studying the facilitation of communication in the mathematics subject area for the purposes of investigating an educational topic as a major assignment for our program. I think that your knowledge and experience will provide insights into this topic.

I am writing a report on this study as a requirement of the Master of Teaching Program. My course instructor who is providing support for the process this year is Dr. Susan Schwartz. My research supervisor is Dr. Cathy Marks Krpan. The purpose of this requirement is to allow us to become familiar with a variety of ways to do research. My data collection consists of a 30 to 45 minute interview that will be tape-recorded. I would be grateful if you would allow me to interview you at a place and time convenient to you. I can conduct the interview at your office or workplace, in a public place, or anywhere else that you might prefer.

The contents of this interview will be used for my assignment, which will include a final paper, as well as informal presentations to my classmates and/or potentially at a conference or publication. I will not use your name or anything else that might identify you in my written work, oral presentations, or publications. This information remains confidential. The only people who will have access to my assignment work will be my research supervisor and my course instructor. You are free to change your mind at any time, and to withdraw even after you have consented to participate. You may decline to answer any specific questions. I will destroy the tape recording after the paper has been presented and/or published which may take up to five years after the data has been collected. There are no known risks or benefits to you for assisting in the project, and I will share with you a copy of my notes to ensure accuracy.

Please sign the attached form, if you agree to be interviewed. The second copy is for your records. Thank you very much for your help.

Yours sincerely,

Marylina Serio
Primary Researcher
marylina.serio@mail.utoronto.ca
I acknowledge that the topic of this interview has been explained to me and that any questions that I have asked have been answered to my satisfaction. I understand that I can withdraw at any time without penalty.

I have read the letter provided to me by Marylina Serio and agree to participate in an interview for the purposes described.

Signature: ________________________________

Name (printed): ________________________________

Date: ________________________________
Appendix B: Interview Questions

I would like to take the opportunity to thank you for agreeing to participate in this interview process in order to further my Master of Teaching Research Project. I am currently conducting research on communication in the mathematics classroom and the extent to which effective communication is being fostered in today’s schools so as to increase students’ conceptual understandings of the materials being taught. The purpose of this interview is to get an understanding of your own perceptions as to the importance of communication in the mathematics classroom and your own experiences with facilitating communication. More specifically this interview will zoom in on any strategies you may have or use in your own classroom to effectively engage students in mathematical talk while dealing with other duties and responsibilities of both the teaching profession and other extenuating pressures.

This interview will be tape-recorded, will consist of 15 questions and will range between 30 to 45 minutes. Any information collected will be used solely for the purposes of this research project and any recordings of your responses, both written and recorded, will be destroyed at the conclusion of this project. In addition, any information or examples that you provide will be kept confidential so that your identity will be concealed.

If at any time throughout the interview process you have any concerns or questions about what is being asked of you, please do not hesitate to stop me and inform me of your concerns.

Before we begin, do you have any questions about the process or purpose of this interview?

Note: When the words student discourse and/or math talk are used in a question, it is referencing teacher facilitated peer-to-peer and student-to-teacher communication where students verbally explain and justify their thinking in small and/or large group activities. These two terms are used interchangeably.

Section 1: Background information of the interviewee
1. How long have you been in the teaching profession?
2. What grade do you currently teach?
3. a) Have you taught mathematics in any other grades?
   b) If so, which grades?
4. Do you have any specific background, courses, PD regarding mathematics?

Section 2: Interviewees’ understandings of the topic at hand
5. What does student discourse and/or math talk mean to you as a mathematics teacher?
6. Do you think that implementing student discourse in mathematics can help students develop a deep understanding of mathematics? Please explain.
7. Have you used student discourse in your mathematics program? If so, how?
Section 3: Interviewees’ perceptions of the benefits of mathematical communication
8. What are some of the differences you notice, if any, in the engagement of your students when you facilitate activities that support student discourse? Please explain.
9. What are some of the effects, if any, on student engagement that you notice if you do not facilitate activities that support student communication?

Section 4: Interviewees’ challenges with mathematical communication
10. In your opinion, is there anything that may affect the impact that communication plays on student’s learning?
11. How do you respond to incorrect student answers during a whole group discussion?
12. In your opinion, what are the biggest challenges, if any, that may prevent teachers from infusing mathematical discourse as part of their mathematics program?

Section 5: Interviewees’ perceptions of his/her own abilities to facilitate mathematical communication
13. How effectively do you feel that you facilitate math talk in your mathematics classroom? Please explain.
14. Are there any ways in which you feel that you might be able to increase student discourse in your mathematics program? Please explain.

Section 6: Suggested strategies to use in mathematics classroom
15. What techniques or strategies do you use in your classroom to facilitate student communication about mathematics and sharing their mathematical thinking?
16. If/when you facilitate mathematical discourse in your classroom can you please describe what you invite students to discuss?
17. Do you pose specific questions to help elicit student discussions? If so, which questions do you feel are most helpful?
18. Do your students talk mostly to you or to their peers?
19. Do you use any strategies to prepare students for communicating their thinking? If so, please explain.
20. What suggestions do you have for teachers that will assist them in facilitating student communication in their mathematics classrooms?
21. What training or professional development, if any, do you feel teachers need in order to support and/or build the skills necessary to effectively facilitate communication in their mathematics classrooms?

Thank you for taking the time to participate in this interview. Your insights and experiences are important and will add value to my research project. If at any point you have any questions or concerns in regards to this interview process, any information that you have provided, or if you wish to withdraw from participating in this research project, please contact me through email or
telephone as provided on the interview consent form. Also, if you have any additional comments about communication in the mathematics classroom please do not hesitate to call or email me as I will love to hear your additional insights. Thank you!