Teachers’ Beliefs and How Those Beliefs Affect Manipulative Use in the Classroom

By

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Abstract

This research study examines the teachers’ beliefs about the use of manipulatives in teaching mathematics and its potential impact on how manipulatives are being implemented in the classroom. A teachers’ belief regarding manipulatives plays an important role in how they are implemented in the classroom. There is a considerable amount of literature that outlines the reasons why manipulatives should be used during mathematical instruction, but there seems to be a lack of literature concerning how manipulatives are being implemented during mathematical instruction. The aim of this paper is to provide insight on the different reasons teachers have for using manipulatives in class. Teacher interviews were used to collect data concerning the teachers’ beliefs and what their current practices are regarding the use of manipulatives such as when and how they are used. The results indicated that there are factors such as past experience that influence how manipulatives are used in the classroom.

Keywords: Mathematics, manipulatives, beliefs, implementation
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INTRODUCTION

Many advocate that using manipulatives is undoubtedly the answer for helping students grasp mathematical concepts during instruction (Uttal, Scudder & DeLoache, 1997; Moyer, 2001; Moyer & Jones, 2004); however, the mere presence of manipulatives is neither effective nor sufficient, and teachers are at the forefront of this problem. The responsibility lies with the teacher to integrate manipulatives during mathematical instruction in a manner that will provide students with clarity and deep understanding of abstract concepts, which means manipulatives need to “engage students in meaningful experiences that promote mathematical understanding” (Moyer & Jones, 2004, pg. 16). If one were to assume this were the case in all classrooms in Canada, student achievement in mathematics would be at an all-time high, yet this is not the case (Carbonneau, Marley & Selig, 2013). Over the past five years, the percentage of students in the primary and junior division performing at or above the provincial standard in mathematics has gradually declined (Ontario Student Achievement, 2013). In fact, Canada as a whole has dropped out of the top ten ranking in international math education standings, and has scored “significantly below the average,” according to the 2012 Programme for International Student Assessment Report (PISA Report VI, 2013). To combat this problem, as stakeholders on the frontlines, it is important that teachers be provided with consistent opportunity to learn how to effectively integrate the use of manipulatives in mathematics instruction. This is particularly important in light of the “fact [is] that many elementary teachers lack the knowledge to teach mathematics with coherence, precision, and reasoning…” (Wu, 2009, pg. 14). Research has found that many teachers feel they do not have the mathematical knowledge to confidently teach students the concepts that are needed for a strong foundation (Wu, 2009). To compensate for the lack of knowledge and to help them gain confidence in the classroom, some teachers have integrated the
use of manipulatives during instruction: “Teachers reported that the use of these manipulatives… helped them make math meaningful” (Vinson, 2001, pg. 91). Yet, the problem lies in that “some teachers use manipulatives… without reflecting on how the use of [manipulatives] may change mathematics instruction” (Moyer, 2001, pg. 178). This problem can then translate into students not reaping the full benefits of using manipulatives as a tool for understanding abstract mathematical concepts because teachers are not integrating them effectively in the classroom. It is important that this problem be addressed given that there has been a dramatic increase in the use of manipulatives in the past decade: they have been pushed by the government, educators, and administrators as an important factor in mathematics education (The Ontario Curriculum, 2005). However, this rise in popularity does not mean that manipulatives are used effectively in the classroom to teach mathematical concepts. The intended purpose of manipulatives is to help students grasp mathematical concepts, yet in the context of an increase in attention to manipulatives and a decrease in mathematical ranking, it is important to learn how teachers are using these in meaningful ways that impact students’ comprehension of mathematical concepts.

With this in mind, the goal of my research is to explore how teachers’ beliefs about manipulatives are influenced by past learning and professional development experiences; how teachers use manipulatives in their practice and how teachers feel manipulatives impact student learning. While reviewing the literature, I have noticed a wealth of data that emphasizes reasons why teachers should use manipulatives during mathematical instruction, but there seems to be a lack of literature concerning how teachers themselves use manipulatives’ during mathematical instruction. I believe my research will provide insight on the different reasons teachers have for using manipulatives in class, as well as where those reasons originate from because “[t]eachers’ views regarding manipulative use are situated in their own assumptions about and experiences in
mathematics and schooling (Moyer & Jones, 2004, pg. 17). The data collected will enable researchers to further explore appropriate strategies that teachers can use when integrating manipulatives in their practice. My central research question for this study is:

What are teachers’ beliefs about manipulatives and how do those beliefs affect manipulative use in the classroom?

My Subquestions are:

1. How do teachers’ past educational and professional development experiences with manipulatives influence their perceptions of the use of manipulatives in their practice?
2. How do teachers perceive the impact of manipulatives on student learning?
3. How do teachers use manipulatives in their mathematics program?

I hope the results of this study will reveal the different ways that teachers use manipulatives and provide information that can be used to inform teacher practice.

As someone who excelled in mathematics, I wish for other students to experience the potential joy that exists when learning and doing math. The decrease in student achievement in mathematics gravely concerns me because I have witnessed firsthand the lack of knowledge, the lack of interest, and an increase in math anxiety in young students. As a tutor, I have worked with many older students who lack even the most basic mathematical concepts such as addition and subtraction – I believe they should have attained this knowledge at an earlier age. One important point to make about mathematics is that it continually builds on a previous concept. If students do not understand the content, his or her misunderstandings will snowball to the point
where they will give up. It is very easy to fall behind in mathematics, which is why teachers need to ensure that students understand the material the moment it is taught.

To respond to the research questions, I will be conducting a qualitative research study using purposeful sampling to interview three teachers regarding their beliefs about manipulatives and its effect on student learning. In chapter two, I review the literature regarding the importance of effective manipulative use and the roles teachers play in ensuring proper use. In chapter three, I elaborate on the research design. In chapter four, I report my findings, and in chapter five, I will discuss my findings and their significance in relation to the literature and the implications for my own practice as a teacher.
CHAPTER 2: LITERATURE REVIEW

Definition

Manipulatives are defined as “…objects designed to represent explicitly and concretely mathematical ideas that are abstract. They have both visual and tactile appeal and can be manipulated by learners through hands-on experience” (Moyer, 2001, pg. 176). Manipulatives can be many things in the classroom: they can be as simple as a folded piece of paper and blocks to something more overtly mathematic like base-ten rods, counting beads and tangrams. Manipulatives can play a crucial role in understanding abstract concepts because they “…provide students with an additional resource to use in learning mathematics” (McNeil & Jarvin, 2007, pg. 312). It is generally understood that the more ways students can learn information, the better students will understand and retain that knowledge because they are activating different parts of the brain for one concept. Another aspect of manipulatives is that they “represent a concept or written symbol… [and] teachers must take into account how children do (or do not) understand symbolic relations” (Uttal, Scudder & DeLoache, 1997, pg. 38). Student understanding of the manipulatives as a symbol for a mathematical concept is pivotal to whether or not manipulatives are used effectively in the classroom. To ensure this, it is important that manipulatives be used as tools where “…students have the opportunity to gain insight into their experience with them” (Moyer, 2001, pg. 176). This goes hand-in-hand with the direction the education system is taking to make mathematics education align more with inquiry-based learning. Manipulatives are the tools that can enable students to “become active participants who construct knowledge by reorganizing their current ways of knowing and extracting coherence and meaning from their experiences” (Moyer, 2001, pg. 176).
The Need for Manipulatives and Why They Are Important

To improve mathematical performance in students, the research has shown that “…mathematics education and cognitive psychology [have] encourage[d] educators to shift from the memorization of facts and algorithms toward instruction that involves students in mathematical concept construction” (Moyer & Jones, 2004, pg. 17). What this shift implies is that teachers should be changing their mathematics template for lesson planning which is known to be called the ‘script’. The script has been unintentionally and culturally ingrained into teachers through observation and participation (Moyer, 2001). Teachers usually follow the script for a math lesson which includes: (1) review previous material, (2) demonstrate how to solve problems for the day, (3) practice problems, and (4) correct seatwork and assign homework (Stigler and Hiebert, 1999, pg. 81). This procedure does not provide students with the ability to become active participants in the classroom, and the instructional strategies that come along with it such as the rote memorization have been proven not to be effective because the work is tedious, mundane and does not offer long-term retention. What has been proven effective is the use of manipulatives for allowing students to construct mathematical concepts and there are several theorists that support the use of them in a classroom. Child developmental theorist Piaget (1952) suggested that children do not have the mental ability to comprehend abstract mathematical concepts and require the hands-on experience with concrete materials in order for learning to occur (specifically in the fourth stage called concrete operational stage). In the four stages of development, he explained how children learn about their environment and thus, start to build schemas about objects in their life. Maria Montessori, another developmental theorist, believed that “…young children naturally focus on the concrete aspects of objects (e.g., shape, size, color), and they are intrinsically motivated to manipulate (e.g., rotate, order, stack) the
objects they encounter in their environment” (McNeil & Uttal, 2009, pg. 137). Both of these theorists advocate that the use of concrete materials is necessary to the learning process which should motivate teachers to use manipulatives during mathematical instruction.

The need for manipulatives also stems from the fact that there are many different types of students, all of whom learn differently. As mentioned previously, manipulatives have tactile appeal which lends itself to kinesthetic learners in what used to be a traditional pen and paper environment. Manipulatives have the ability to reach a wider range of students by offering a variety of ways to learn a concept which increases understanding and retention. An example of this was presented by McNeil and Jarvin’s (2007) study in which a teacher is trying to get students to learn about the formula for the area of a triangle derived from the formula for the area of a rectangle. The teacher initially used the chalkboard to draw diagrams and explained the concept verbally to the class. In addition to those instructions, the teacher also got the students involved by using the geoboard to cement their lesson. The students were able to comprehend what the teacher was instructing and apply the visual diagram on the board. The manipulation of the geoboard confirmed the concept, while touching upon multiple intelligences.

Another reason why manipulatives are important to the classroom is that they can “help children draw on their practical, real-world knowledge” (McNeil & Jarvin, 2007, pg. 311). Research has shown that learning is more effective when new knowledge is built upon old knowledge and teachers should be building upon the schemas that children have of the world. A renowned study conducted by Carraher, Carraher, and Schliemann (1985) found that manipulatives are able to cue children’s real-world knowledge; however, there is a lot of debate regarding this topic (Kaminski, Sloutsky, & Heckler, 2009). Other research has shown that “a given manipulative needs to be represented not only as an object in its own right, but also as a
symbol of a mathematical concept or procedure” (McNeil & Jarvin, 2007, pg. 313). This idea will be explored in the following section.

**Why Manipulatives May Be Ineffective**

There are those who claim that manipulatives are the answer to improving mathematical understanding and performance, as long as the teacher uses them effectively (Moyer, 2001; Vinson, 2001). Teachers form the frontline of our education system and they must understand the proper context in which to use manipulatives in order for them to be effective. As noted above, manipulatives represent symbols for abstract concepts and the challenge that teachers may face when using manipulatives is that they “lack the mathematical competencies to transform mathematical ideas into representations” (Moyer, 2001, pg. 178). If teachers are unable to make the symbolic connection from concrete materials to abstract concepts themselves, then the student’s comprehension will be constrained by their teachers limitations and not develop the deep understanding mathematics requires. In other words, if teachers do not understand mathematical representations of an abstract concept, then there is a high possibility that students will not either. Teachers need to be trained and qualified to teach mathematics to students because they are supposed to be the conveyors of knowledge and it has been shown that “teachers attitudes were directly linked to student performance in and student attitudes toward mathematics” (Vinson, 2001, pg. 90). Therefore, the teachers need to be confident in understanding the mathematical concepts while working with manipulatives in order for students to feel that way as well.

Teachers’ knowledge, or lack thereof, of math also affects how manipulatives are being used in the classroom (Vinson, 2001). Manipulatives are intended as tools to reinforce a math
lesson that will deepen students’ understandings; however, some teachers see them differently and thus, use manipulatives in other ways that are not conducive to the lesson. In a 2001 study conducted by Moyer, results showed that the teachers in the study divided their math lessons into ‘fun math’ and ‘real math’. Teachers described ‘real math’ as the traditional paper and pen lesson and ‘fun math’ to be exploration time with the manipulatives or used as a reward for finishing work. The problem lies is that “using manipulatives for ‘fun math’, teachers artificially set up a classroom situation in which materials may not be used effectively” (Moyer, 2001, pg. 191). Students have a different mindset and will change their thought process when the teacher changes the setting or atmosphere to be ‘fun’. Students will see manipulatives as games when it should be supporting the math lesson and make meaning from that experience (Moyer, 2001.) It makes math and fun two separate and distinct entities, when it would be more productive if they were one and the same.

Another problem that students may encounter with manipulatives is that they have “to interpret the manipulative as a representation of something else” and “[a] concrete manipulative may be interesting to young children, but this is not sufficient to advance their knowledge of mathematics concepts” (Uttal, Scudder & DeLoache, 1997, pg. 39). When children see an object, they classify and label it as its own separate entity and to teach those same objects to represent something else may be hard to understand if they are not developmentally ready. Uttal, Scudder and DeLoache (1997) have used the dual-representation hypothesis to explain this phenomenon, suggesting that “the relation between manipulatives and their intended referents may not be transparent to children” (pg. 44). Children might only see the manipulatives as what they are – physical objects – and not make the connection to the concept in a mathematics lesson. Although Piaget supports the use of concrete materials, he also makes a point to say that children have to
be at a certain developmental stage in order to grasp abstract concepts. This means that teachers need to be cognizant of when manipulatives should be incorporated into the lesson, and also pay particular attention to which types of manipulatives to use so they do not create confusion for students.

**Making Manipulatives Successful**

Like instruments for a music class, or a telescope for science class, “[m]anipulatives are not, of themselves, carriers of meaning or insight” (Moyer, 2001, pg. 176). They have to be used in conjunction with a sound mathematics lesson in order to be effective at grasping abstract concepts. With manipulatives, students have the ability to gain insight into their experience with them which will make learning all the more interesting and engaging. The education system is attempting to reform by implementing the inquiry process into its curriculum and manipulatives enable mathematics to be a part of that process. It may seem evident that inquiry might be more conducive to subjects like science or history, but through the use of manipulatives students are able to construct concepts in a way that is meaningful to them. Teachers play an important role as both the facilitator and guide in discovering abstract concepts because “[a]n important characteristic of programs that successfully use manipulatives is that instruction and manipulative use are linked from the outset” (Uttal, Scudder & DeLoache, 1997, pg. 49). Math is not an easy subject and it should not be assumed that students should or would get abstract concepts on their own. It is important to emphasize that teachers have the capacity to use manipulatives in an effective manner, but only if they have the knowledge to do so. This implies that pre-service teachers should be well educated in the field of mathematics and in-service teachers should professionally continue to develop their skills through workshops and
conferences. The fact of the matter is, the more teachers know about a concept, “the more likely it is that they can make it accessible to their students” (Wu, 2009, pg. 381).
CHAPTER 3: METHODOLOGY

My study will investigate teachers’ beliefs about manipulatives and how those beliefs affect manipulative use in the classroom. This research study relies on qualitative data collection methods, review of the literature, face-to-face interviews with three practicing junior/intermediate school teachers working in Ontario, and analysis and evaluation of the data collected. Qualitative research was appropriate for my study because I would like to further explore manipulative use in the classroom through the teacher’s voice. There is much data from the perspectives of researchers and theorists on the benefits of manipulatives use for students; however the research is lacking on the actual implementation of manipulatives and teacher’s attitudes towards them. Quantitative measures and statistical analyses would not provide sufficient or detailed data for my research, thus qualitative was the most appropriate (Cresswell, 2013).

Participants

To find participants for my study I used the purposive sampling approach because these individuals “can purposefully inform an understanding of the research problem” (Cresswell, 2013, pg. 156). More specifically, I used the maximum variation strategy in order to “document diverse variations of individuals… based on specific characteristics” (Cresswell, 2013, pg. 158). This ensured that I studied multiple perspectives when it comes to manipulative use to capture a true image of what teacher’s attitudes are like across all the school boards.

I would like interview three teachers who have taught for over five years. In particular, I would like them to be junior and intermediate teachers who are currently teaching grades 4-8. I am choosing to focus on the junior and intermediate grades because the concepts increase in
difficulty at this level and manipulatives may be used more during mathematics lessons. My three participants will also have varying levels of competency in mathematical knowledge. I think this will best capture a variety of perspectives. I will select my participants based on connections I made from my practicum experiences during the Master of Teaching program. The criteria I would be looking for in my participants are that they must be currently teaching math at a junior or intermediate grade level.

Procedure

Before I started the interviews with my participants, I conducted a literature review about manipulative use in mathematics. Throughout my research, I was able to define what manipulatives are and discovered the lack of data on teacher use of manipulatives while simultaneously discovering the immense benefits of manipulative use for students; this further drives the need to investigate why more research needs to be conducted in this area and this helped me hone in on my research problem. Afterwards, I began the process of preparing my questions for the face-to-face interviews with my participants. Subsequently, I found my three participants and started the interview process. The interviews were guided by the open ended questions I prepared, however the discussion was not limited to those topics as other subject areas were brought up that were pertinent to the study. All the interviews were recorded to be transcribed and coded. While coding for the data, an analysis of the codes were conducted to find themes that had emerged. Lastly, the significance of the findings are discussed and compared to the literature.
Data Collection and Analysis

I started looking for my participants after I had finished preparing the interview questions while keeping in mind the ethical protocol. After I have found my three teachers, I conducted two face-to-face interviews and one telephone interview that lasted on average about 30 minutes. The interviews were semi-structured interviews with thirteen open-ended questions and the goal of each interview is to “encourage the person to speak in their own words to obtain a first person account” (Packer, 2011, pg. 43). For the purpose of my research, I chose semi-structured interviews because there is a “great deal of latitude in the way they answer, the length of their responses, and even the topics they discuss” (Packer, 2011, pg. 43). In their responses, I hoped to capture the experiences teachers have with manipulatives and given the function of the semi-structured interview, it did “allow[] the participants to contribute as much detailed information as they desire[d] and it also allow[ed] the researcher to ask probing questions as a means of follow-up” (Turner, 2010, p. 2). A draft of the interview questions can be found in Appendix A. After the interview had been conducted, I transcribed my interviews and coded for themes that were prominent throughout my literature review and potentially answered my research problem. There were around twenty-four codes that were found consistently within the data. I further organized the codes into categories, from which I eventually found the themes that will be discussed in chapter four.

Ethical Review Procedures

Prior to this research study, an ethical review was conducted by the review board for the Master of Teaching Program. It stipulated that data collected will only be from participants who are knowledgeable educators that will provide expertise in my research topic. Interviewees will
be contacted in advance and if the participant agrees to be interviewed then they will be presented with a letter of informed consent. The interview will be conducted outside of school hours and not on school property but at the participant’s convenience. The participant will also be informed that they can stop the interview at any time and withdraw from the study completely. The participants were also aware that the interviews would be recorded by an electronic device and later used for data analysis. A draft of the Letter of Informed Consent can be found in Appendix B.

**Limitations**

The biggest limitation for my research study is the inability to conduct classroom observations while the teacher is using manipulatives in their lessons. It is a key tool for qualitative research to understand the phenomenon being studied in their natural environment (Cresswell, 2013); however I am limited by the Master of Teaching program’s ethical protocol. Observations would have provided my interviews with more validity and reliability to see if the interviewees are giving a true account of what it is they are saying and believing. Another limitation in my research study is the sample size. Given the time constraint of the Master of Teaching program, interviewing only three participants was feasible. In order to get a true account of what teachers’ beliefs are towards manipulatives and their effects on manipulative use in the classroom, I would need a larger sample size for a true representation of the population. Also, if I had more participants that would more likely represent the views and current practices of Ontario elementary school teachers.
**Strengths**

Despite these limitations, I hope my research can provide the impetus for further studies in the area of teacher use of manipulatives. Conducting this study, especially using qualitative methods “can… uncover details that allow the researcher to gain a deeper understanding of the participants than he or she could acquire through quantitative methods” (Van Den Hoonaard, 2012, pg. 3). This deep understanding of manipulative use in the classroom will enable policymakers/administrators to make informed decisions about what kind of training is needed for pre-service teachers or professional development courses for current teachers, on the effective use of manipulatives. My study will also provide further insight for those who are interested in learning more about the implementation of manipulatives in mathematics. The qualitative data that is collected is very important because as researchers, we need to understand that “an individual’s behaviour is [heavily] influenced by her or his social situation and past experiences” (Van Den Hoonaard, 2012, pg. 16). My participants’ social situation and past experiences can provide the insight needed to determine what kinds of experiences promote good practice. More importantly, my research study will give my participants’ a voice in which they can share their insights.
Chapter 4: FINDINGS

This chapter will highlight the main findings of the data collected from the interviews with the three participants in this study. These interviews proved very informative and provided a wide range of data; additionally, several themes emerged regarding each teacher’s use of manipulatives in the classroom. First, the participants will be introduced and then a discussion of the emerging themes will follow. For each theme, I will report the pertinent data and include participant voices to support my analysis. My intention is to give an accurate representation of the main ideas that were revealed by the data and situate my findings within the current literature.

Participant Information

The participants will be referred to in this research by pseudonyms to maintain their anonymity. The following is an overview of their teaching experience in mathematics. Curt has been teaching for 13 years. Of the 13 years, he has taught mathematics for 12 years at a junior grade level. John has been teaching for 27 years. He has taught all grades up to grade 8, with mathematics being his core subject. Amy has been teaching mathematics for 9 years at a primary/junior grade level.

Themes

There are four main themes and subthemes that emerged as a result of the data obtained: Teachers’ past education and/or professional development related to the use of manipulatives; the implementation of manipulatives; teachers’ perceptions of the benefits of infusing
manipulatives in mathematics and teachers’ perceptions of the impact manipulatives on student learning.

**Teachers’ Past Education and Professional Development Related to the Use of Manipulatives**

*Past educational experiences.* A study conducted by Opdenakker and Damme (2006) found that teachers’ background characteristics are related to teaching practices. This lead to ask about the participant’s past experience with manipulatives when they themselves were students which provided some insights of their stance on manipulatives. Coincidentally, they all took a moment to pause and deeply think about their past. All of the participants answered that they did not recall using a lot of manipulatives in school, especially compared to the constant presence manipulatives have now in schools. John and Amy both said they remembered the use of calculator’s, although for Amy’s school experience, “they stress not using it cause they would want you to be able to use your brain more.” Despite the fact that all the participants did not use manipulatives themselves when they were younger, they have all stated that they are firm believers that manipulatives are important tools in helping students better understand mathematical concepts in more meaningful ways and have fully implemented manipulatives in their classroom.

More specifically, John admitted his past experience with mathematics was a “challenge to [him] because of the way it was taught.” He felt he had “terrible teachers” but through his own “perseverance” he taught himself and with that he improved greatly. This experience motivated John to be the math teacher he is today stating, “I believe why I am so effective with teaching this subject to my students because I fully understand their struggles and my strategies
to assist my pupils help them overcome their challenges in mathematics” (Teacher interview, January 4, 2015. John implements a successful balanced math program that emphasizes the importance of manipulatives and has run professional development workshops for fellow colleagues.

Another commonality that all three participants had was how they self-identified as either visual and/or kinesthetic learners. Being a visual learner meant that Amy could “remember things more” and “doing it made it stick.” That is not surprising because many studies (McNeil & Jarvin, 2007; Gardner, 2011) have shown that the more ways a student learns a concept, the better the student understands and retains the knowledge. Curt mirrored that exact notion in his interview:

I've always identified with being primarily a kinesthetic learner--I found that by having something concrete to manipulate helped me remember and retain information/knowledge better. I've always been fascinated by math and science probably because of my interest in "hands-on" authentic learning opportunities these disciplines provided. (Teacher interview, December 1, 2014)

Curt’s interest in ““hands-on’ authentic learning opportunities” has trickled down into his classroom where he uses manipulatives in many of his lessons such has teaching geometry with 3D solids for his students to then build robots with the knowledge of those concepts.

**Professional development and administrative support.** There is now a wealth of literature that has proven how effective manipulatives can be in supporting student learning (Stein & Bovalino, 2001; Puchner, Taylor, & et al., 2008; Boggan, Harper & Whitmire, 2010). That data has trickled down and can be seen in the Math Curriculum document where it states that students are “encouraged to select and use concrete learning tools to make models of mathematical ideas” (Math Curriculum, 2005). With the Ministry of Ontario pushing for the use
of manipulatives in the classroom, school boards are making a tremendous effort in providing their teachers with the appropriate training on how to use manipulatives. Two of the participants said that mathematics is one of their school board’s main focuses, as they are looking to increase student math scores for the standardized test students write in grades 3, 6 and 9 across Ontario. In his interview, Curt said “this year the big push in our board is math and getting the kids to understand, and so you know you think of literacy and that’s an important component but there’s also being you know being math literate that is very important” (Teacher interview, December 1, 2014).

The school board that the other participant is currently working in also shares the same views regarding mathematics. The mission of John’s school board is reflected in his own personal beliefs in terms of improving student understanding of mathematics with manipulatives. For professional development, John attends math conferences “usually at least once a year” to stay current and up-to-date on education and mathematics research (Teacher interview, January 4, 2015). One of the factors associated with successful implementation of manipulatives is the training teachers receive in the use of manipulatives. He uses the information he learns about manipulatives and applies them to his own classroom. John also mentioned that he learns from his own Teacher Candidates and is willing to experiment with new teaching methods with his class.

One of the things mentioned that is very helpful when learning about manipulatives is the format of the mathematics workshops that teachers attend that are provided by the school administrator. They are taught in a very hands-on manner that emulates what it should be like the classroom. This is very valuable for teachers because they are learning how to properly use
manipulatives from experts, and have the opportunity to ask questions about difficulties that may arise in the classroom. Amy discusses this in her interview:

She, [a resource teacher who specializes in mathematics manipulatives] comes in, she does PD with us and then she will inform us of different types of strategies we can use and how we can use the manipulatives…. So then she will sometimes have us participate in how these things work so we’ll know what to expect from the kids. (Teacher interview, January 28, 2015)

With this knowledge, Amy feels that she is equipped to use manipulatives in an effective manner. As previously mentioned, manipulatives can be ineffective when “teachers leave students too much to their own devices, resulting in unsystemic and nonproductive exploration” (Stein and Bovalino, 2001, p. 356).

**Implementation of Manipulatives**

Several of my interview questions aimed to get a better understanding of how teachers’ implemented manipulatives into their lessons and classrooms. It was important to gain knowledge about how manipulatives are used in the classroom in order to gather information about their beliefs of manipulatives.

*When manipulatives are implemented.* It is essential that manipulatives are seen as intrinsic to the learning of mathematical concepts. Manipulatives have the ability to model and represent abstract concepts for students in a real world setting: “[l]earning theorists have suggested for some time that children’s’ concepts evolve through direct interaction with the environment, and materials [i.e. manipulatives] provide a vehicle through which this can happen… [because] [m]athematics in its purest sense is an abstraction” (Post, 1981, pg. 109). Therefore, one of my interview questions examined specifically when manipulatives are
implemented in a lesson whether at the beginning, middle or end. This could be an indicator of the value of manipulatives as a learning tool. One of the responses I received was from Amy who stated that she incorporated wherever possible:

All the time. Because you use it to model what you’re looking for or the concept; during so they can get the practice of it and after it’s the checking of their understanding. So some kids by the time they use it, they don’t need it in the end but there is some who will need it so I use it all the time because it gives them the opportunity to do it.

(Teacher interview, January 28, 2015)

Amy believed that it was important for students to be exposed to manipulatives during the entire learning process of the lesson. The work of Jean Piaget (1952) discovered that children learn best through doing and actively exploring and that the role of the teacher is to facilitate learning and encourage active discovery. Amy reinforces this idea as she uses manipulatives throughout her lesson to promote active discovery which in turn, helps students learn mathematical concepts. Piaget believed that children go from the concrete, to pictorial to symbolic which coincides with Amy’s lesson outline.

John felt that the time of year, instead of where manipulatives were used in his lessons was critical. John teaches mathematics using a balanced math program in his class where he would use a whole class approach to “initiate [his] lesson just to make sure everyone has a broad spectrum of what’s going to happen and then [he] would go into [their] centers” and so manipulatives are always present (Teacher interview, January 4, 2015). What was important for him in terms of timing was exposing students to all sorts of manipulatives when the school year started and setting the tone for manipulatives as a “valuable tool” and to “set that precedent at the beginning.” This is evident in the quote below:

…so for me as a teacher, that’s where September and October becomes extremely important with the student’s being able to
be inundated with as many manipulatives as possible so that as the year progresses, they can make their choice as to what’s going to be best to support them in their learning, or their understanding. (Teacher interview, January 4, 2015)

The important focus here is how manipulatives play a big role in engaging students in the mathematical process and not just understanding mathematical content. Teachers should also focus on the mathematical process skills which will empower students mathematically at all levels. The Ontario Mathematics Curriculum emphasizes the important role of the mathematical processes for students to acquire and apply mathematical knowledge and skill (Math Curriculum, 2005). John’s thoughts coincide with the mathematical skill of selecting tools and computational strategies. Students need to develop the ability to select the appropriate tools to perform mathematical tasks, to investigate mathematical ideas, and to solve problems. Students need to use the appropriate manipulatives to develop the understanding of new concepts, for communicating, or for completing activities. John has specifically allotted time for students to develop this skill which he believes will help students all throughout the year.

*How manipulatives are implemented.* The teachers shared that manipulatives are implemented in various ways throughout a mathematics lesson while teaching a variety of concepts. They could see multiple uses for manipulatives in terms of purpose. Curt gave an example of how he used manipulatives sometimes as a minds-on activity where the “kids will come in and the manipulatives will be set up by their desks so they jump right in” (Teacher interview, December 1, 2014). The teachers felt that giving students the opportunity to explore the manipulatives allows the students to become familiar with the manipulatives themselves and make the connections between the concrete with the abstract concepts later on in the lesson.
One of the ways John uses manipulatives is as an assessment tool because he believes that in order to be an effective mathematics teacher “we need to be able to look at what the child knows, what their learning and then finally what have they learned overall, that’s the ultimate goal” (Teacher interview, January 4, 2015). This is how he uses it as an assessment for learning:

So with that said sometimes I give a quiz like a diagnostic to say I want you to use this particular manipulative and see what you can do with it based on the questions that I am posing. If I get a blank from the kids then I know that they haven’t been exposed to it and that’s where I’m saying to it, please understand that this is just diagnostic, don’t become anxious about it, I don’t want to create a math phobia if anything I am trying to do the opposite, to make sure that they really are comfortable and enjoy mathematics. So with that said, if the quiz comes back zero, I’m not going to be angry with the students, it’s just hey you don’t know this and its now my role, my job to make sure that you understand it or in the other case, it might be where the majority of the class get perfect on a simple quiz of 5 or 10 marks, great let’s move on. (Teacher interview, January 4, 2015)

Another use for manipulatives is how the teachers’ incorporated them in lessons where the focus was on application and not just supporting the learning of abstract concepts. The teacher’s thought it was a useful tool where students can articulate their thinking for big projects. The following is an example where students in Curt’s class were able to use manipulatives in applying their understanding to the real world.

…there’s a project I’ve used for a couple of years uh last year with the grade 5’s where they would have to create uh given a certain uh specification and volume, they would have to create like robot or whatever and they would have to include uh you know all the information like the surface area and what the volume is so yea. (Teacher interview, December 1, 2014)

Challenges implementing manipulatives. All three teachers’ said without hesitation that the biggest challenge in implementing manipulatives was time. The reason being that:
To use the manipulatives then you have to factor in [time], they have to have enough time to use them um they have to have enough time to play with them or to figure things out and that takes time because either they’re working as a group and they have to figure things out or they are doing it independently then they have to go through the process of figuring out what they have to do. (Teacher interview, January 28, 2015)

To compensate for this challenge, the teachers’ thought that they would use their own professional judgment in scheduling the right amount of time needed for that particular math lesson which varies from topic to topic. John said that, “I have the professional discretion to extend my class so sometimes I’ll do a double period which is 100 minutes of math or the next day I might cut back on it” (Teacher interview, January 4, 2015).

Another challenge Amy mentioned was regarding resources. She stated that, “…you’d want them to have enough so that everyone can get a part of the experience but sometimes there aren’t enough resources to do that so whereas it’s better for them to do it in partners, you may have to do it in groups of fours because of what you have” (Teacher interview, January 28, 2015). Although she admits that she is from a school that is privileged in terms financial resources from the parent and school council, it is a reality that there are certain schools that do not have the advantage and thus, do not benefit from a variety of manipulatives. Availability is one of the most important factors affecting the use of manipulatives because if they are not there, than teachers cannot use them.

**Teachers’ Perceptions of the Benefits of Infusing Manipulatives in Mathematics**

*Physical and concrete representation of abstract concepts.* One of the biggest benefits that the teachers discussed was having something tangible for the students to physically manipulate as they are learning mathematical concepts. There are areas of the math curriculum
that are typically difficult for students to grasp and the teacher’s feel manipulatives are very useful in representing those abstract concepts. For example, Amy thought manipulatives are helpful in understanding regrouping: “I think it’s helpful because students learn in different ways and so for some students it’s really important that they have that hands-on. So some students, they can look at things and they get it immediately but for some they need to see it. For example, base ten blocks, lots of kids don’t get the regrouping until they actually see those units being stuck together and broken apart” (Teacher interview, January 28, 2015).

Another example of a difficult topic for students to grasp is fractions. The reason why fractions are challenging for students is because they involved relations between quantities. In other words, “it requires that [students] realise that the same fraction may refer to different quantities and that different fractions may be equivalent because they refer to the same quantity” (Teaching and Learning, 2006). Curt explains: “…fractions are really difficult for the kids, they don’t have a strong understanding of it at least when they come to my class. At our school, we’re on the cutting edge of uh doing phenomenal work in mathematics but to solidify that understanding, it’s a lot of abstract, so for the students to understand you know the addition and the subtraction of fractions um before I get them into the multiplication and division of fractions uh these manipulatives become very helpful” (Teacher interview, January 4, 2015).

Enhance understanding of mathematics. All of the teachers that I interviewed understood that manipulatives were not the panacea that most people thought they would be. Curt, John and Amy, understood that manipulatives were tools to enhance learning and understanding, and one should not assume that manipulatives alone will enable students to automatically understand mathematical concepts. John states that, “…manipulatives are tools
that can be used by students, in fact by teachers, to help strengthen uh the students understanding of concepts. It shouldn’t be used just to solely teach a concept but it’s intended to support the students in their understanding of a concept” (Teacher interview, January 4, 2015). When used effectively, manipulatives are able to provide students with solutions for problem solving and enrichment of concepts (Moyer, 2001). It is the teacher’s responsibility to provide students the manipulatives themselves and guidance on how to use the manipulatives because there are many purposes for manipulatives. Amy describes in her interview how different students use different types of manipulatives such as one student may use blocks to learn one concept and another student may use base ten blocks for that same concept – her students are given the choice to use whatever they need to enhance their learning (Teacher interview, January 28, 2015).

Curt also brought up an important point that I had not thought of before in terms of manipulatives. He mentioned how in his school there was a high population of English Language Learners and manipulatives enabled those students to understand the mathematical concepts being taught even though they may not grasp the English vocabulary associated with the lessons. Curt describes, “we’re a school where there’s a high component of ESL, where you know you’re using language they might not understand it, but if you draw it on paper or if you build it and show a graph with blocks they get it right away so I think it’s been very useful” (Teacher interview, December 1, 2014). There has been studies conducted that have shown “using manipulatives is especially useful for teaching low-achievers, students with learning disabilities, and English language learners” (Boggan, Harper, & Whitmire, 2010, p. 5).

Students are active learners. Active learning focuses the responsibility of the learning on the learner. Especially for mathematics, students should not be passive listeners but actively
engage in the lesson to better understand concepts and transfer their learning to other things. Curt believes manipulatives can be an avenue in which students become active learners:
“[Manipulatives are] very useful. It’s very important in the learning process because kids learn by actually being active and so that it’s very useful and it’s say a proven technique and it works well so and they were right, it is effective” (Teacher interview, December 1, 2014).

Setting up the classroom environment where manipulatives are readily available allows students to be active learners. John had established his expectations regarding manipulatives right from the beginning of the school. He had taught his students what the different manipulatives are and how they could be used as tools to support learning and as the year progresses, the students are able to independently use manipulatives for problem solving without any specific instructions on how they should be used. John explains how in “January and let’s say I have my bucket of algebra tiles out, I know that at this point the students can simply work on their tasks, whether it’s independent or group problem solving using the manipulatives” (Teacher interview, January 4, 2015). In this scenario with the free access to manipulatives, the students are encouraged to think autonomously and make sense of the mathematics on their own. One study has shown that it is very beneficial for students to have choice when working with manipulatives because it can promote confidence and autonomy in learning mathematics:
“Students had time to explore the uses of the tools, time to investigate how these materials might be used and manipulated, time to examine attributes of the materials, and time to construct their own understanding of mathematical ideas” (Moyer & Jones, 2004, p. 28).

Catering to multiple intelligences. There are many different types of students in our classroom and they all learn differently. As mentioned previously, manipulatives have tactile
appeal which lends itself to kinesthetic and visual learners. All three teachers felt that manipulatives have the ability to reach a wider range of students by offering different ways of learning a mathematical concept and catering to their different intelligences can increase their understanding. John did not just see the benefits of math manipulatives but manipulatives across all subjects: “I’m a very strong believer in math manipulatives, in fact I should just say, math manipulatives, but manipulatives in general especially when we consider the multiple intelligences of kids and being able to strengthen their learning” (Teacher interview, January 4, 2015). Studies have shown that the more ways students can learn information, the better students can retain that information which is very important in mathematics when mathematical concepts continually build on one another from one year to the next (Carbonneau, Marley, & Selig, 2013).

Teachers’ Perceptions of the Impact of Manipulatives on Student Learning

Curt, John and Amy all unequivocally believe that manipulatives are very beneficial to student learning. They all have very similar ideas of what success looks like in the classroom when manipulatives are involved.

Amy believes that manipulatives enable students to learn when they do not even realize they are learning. The atmosphere for a lesson with manipulatives is more fun than a “typical math lesson,” thus the students are more engaged and excited. She has seen this recently in a patterning lesson using patterning blocks and describes it as such:

Oh their excited! So like we just did patterning and you just put a whole bunch of patterning blocks on their desks and then they just have to come up with different patterns or whatever. Um it makes it fun when you decide that they should try and stump their partner to come up with this great pattern and stuff so they are competitive, so then they like doing it. Right and for some they see it as fun when their doing this, they don’t see it as learning O this is fun this
fun as opposed to doing the same thing and drawing the picture or writing it and they go Ugh not again, but yes they are excited when they get to build things. (Teacher interview, January 28, 2015)

Another way of measuring success using manipulatives is to look at a student’s comfort level in a mathematics class. Both Curt and John, feel that manipulatives have the ability to make students feel comfortable with mathematics. Manipulatives are able to take something that may be really abstract and hard to understand to a realm of real understanding when they can visually see it and do not have to imagine it. When math is not difficult for students then they can come to really enjoy it. John explains that he does not want his students to be “anxious about it, I don’t want to create a math phobia if anything I am trying to do the opposite, to make sure that they really are comfortable and enjoy mathematics.” (Teacher interview, January 4, 2015) Studies have shown that when “students work with manipulatives… math anxiety is also greatly reduced” (Boggan, Harper & Whitmire, 2010, pg. 4).
CHAPTER 5: DISCUSSION

The following chapter discusses the purpose of this study proposed in Chapter One with a discussion of the findings, the recommendations and implications for future studies, as well as the limitations of this research project.

Findings

As outlined in Chapter One, the purpose of this study was to discover what teachers’ beliefs about manipulatives are and how do those beliefs affect manipulative use in the classroom. In addition, this study was to provide insight on the different reasons teachers have for using manipulatives in the class as well as where those reasons originate from. My goal was to add to the literature concerning how teachers themselves use manipulatives’ during mathematical instruction.

The findings outlined in Chapter 4 determined that the teacher’s strongly believe manipulatives are an essential tool in the teaching of mathematics. All three participants shared many of the same ideas regarding manipulatives such as defining them as concrete objects that allow students to better understand abstract mathematics concepts. They also believed that manipulatives have visual and tactile appeal which can really engage students especially those who are visual and kinesthetic learners. However, how each teacher implemented and used manipulatives in the class slightly differed. Manipulatives were used at different points in a lesson, used in different subject areas, and used in different ways to teach concepts. This leads me to believe that a teachers’ belief plays a big role in how manipulatives are used and implemented. I will further explore my findings through my sub-questions outlined in Chapter One.
Impact of past educational experiences and professional development. My findings do indicate that teachers’ past educational and professional development experiences with manipulatives influence their use of manipulatives in their practice. Even though all three participants had very limited experience with manipulatives when they were younger, as teacher’s now, they understand the crucial role manipulatives play in understanding mathematics. I believe this is because they all struggled at some point in math in the traditional pen and paper environment. In this struggle, my participants have come to appreciate the value that manipulatives have in helping students grasp difficult abstract concepts, as they all voiced that they wish they had these resources back then to help them. It is interesting that the lack of past experiences with manipulatives did not seem to hinder the participants’ use of them in the classrooms. It was more their own personal struggle to learn and understand mathematics that encouraged them to use manipulatives in their teaching. Another commonality that my participants share is how they consider themselves kinesthetic and visual learners. Because they themselves understand how the act of manipulating concrete objects can further understanding, I feel like they can better relate to the experience of students in a math class. This may point to teachers’ learning styles as possibly having an influence on how they implement manipulatives in their classrooms.

The participants’ experiences with professional development also played a role in their use of manipulatives in the classroom. Professional development is the ongoing learning that any profession has where people learn and apply new knowledge and skills to improve their performance on the job (Mizell, 2010). It seems that this definition aligns well with the experiences that the participants had with professional development in their school districts. All of the participants believed in implementing best teaching practices and in order to do that, they
continued with professional development regarding mathematics, some of which manipulatives were the main focus. I believe this plays a factor in how the teachers’ are using manipulatives in the classroom. In the data that I collected, all the teacher’s shared similar views on the role of manipulatives and implemented them in similar ways. The professional development courses they have taken could be one of the reasons why all of their views and experiences with manipulatives are similar.

**Teachers’ perception of the impact of manipulatives on student learning.** Studies have shown there is a strong association between a teachers’ belief of the effectiveness of manipulatives and the perceived impact on student learning (Vinson, 2001). If teacher’s believe that manipulatives are effective at teaching math, then and only then, would they believe that manipulatives have a positive effect on student learning. My findings aligned with the literature as all three teachers’ strongly believed that manipulatives played a crucial role in the classroom and also used them extensively in their practice. They all believed that manipulatives were tools to enhance learning and understanding – however, what that exactly meant to each teacher was different. The teachers felt that one way of measuring the impact of manipulatives was based on the level of engagement of the students during instruction. One of the participants believed manipulatives enabled her students to learn in a manner where they do not realize they were learning, which she then considers a successful math lesson. Another participant measured the success of student learning with manipulatives by how comfortable he thought the students felt with mathematics. In today’s society where academics and grades are regarded so highly, many students do feel anxious about math and even more so when they feel they are not good at it. Two of the participants believed manipulatives had the ability to make students feel comfortable
with mathematics because they were able to take something concrete and transform the idea into something that was once difficult to understand and really abstract. These findings are important because the participants own experiences with math may have shaped how they perceive the impact of manipulatives on student learning. The participants use measures of engagement and levels of anxiety to gage the success of manipulative use in a mathematics lesson, which are feelings that they have expressed previously regarding their own learning experiences without manipulatives. It is essential for teachers’ to understand how their own experiences may affect their teaching practices. In these three instances, the outcome was beneficial because they used manipulatives in a way that they all knew to be effective because of their own experiences, but there may be other teachers who do not have strong beliefs regarding manipulatives and will experience poor results with manipulatives in the classroom.

**Implementation of manipulatives.** The participants used manipulatives in a variety of ways. The consensus was that the manipulatives would be used as tools to support learning, aligning with studies conducted by Moyer and Jones (2004). One of the participants used manipulatives as a diagnostic assessment tool to get a baseline of what the students know. Another participant used manipulatives to help students grasp extremely hard concepts such as fractions. Curt also described a unit he implemented where he used lots of different manipulatives such as fraction circles and fraction bars to reinforce the concepts. One of participants also used manipulatives as a minds-on activity exploring geometric solids were students were to figure out the faces, vertices and edges. One view that was consistent throughout the data was that all participants were willing and able to incorporate manipulatives wherever and whenever they could – they all saw the advantages of implementing manipulatives
in the classroom. All of the participants continually attend mathematics workshops to stay current on the research regarding manipulatives which is a testament to how strongly they feel about the effectiveness of manipulatives in improving student learning.

**Implications for My Future Teachings**

As a result of the research conducted in this study, I have realized that it is not enough to just have manipulatives incorporated into a mathematics lesson or to assume that students will naturally understand the concepts just because they are there. Manipulatives need to be explicitly taught with the lesson for students to fully grasp the abstract concepts. As a teacher, I need to reflect on how the use of representation is conveyed in my lesson; if manipulatives are not taught properly then students will be more confused than with a lesson without manipulatives. I will make my classroom a place of active learning and not follow the past ‘scripts’ that are typically used for a math class. Manipulatives have the ability to help students gain insight into their experience which makes learning more interesting and engaging. In addition, I want to avoid using manipulatives as games to fill class time. This misuse may lead student dismiss manipulatives as toys and not value the impact these tools could have on their learning.

**Implications for the Education Community**

One key implication of my study is that teachers’ beliefs about manipulatives can have an impact on how teachers use manipulatives in their practice. Thus, in order to promote effective instructional strategies using manipulatives, more research is needed on the current practices of teachers and how specific beliefs affect those practices because, “[a] teacher’s beliefs are intertwined with her/his actions. There is not simply some correlation; beliefs orient action and
actions condition beliefs on an on-going basis” (Moyer, 2001, p. 191). Teachers’ should use reflective practices such as teacher diary, conferencing with other colleagues, or recording lessons, to understand what their beliefs are and where they stem from. Only then could they be cognizant of what kind of practices they are implementing in the classroom which could lead to effective teaching practices. There has been a significant paradigm shift in mathematics education where the focus goes beyond memorizing facts and procedures. Students need to become active participants in the learning process, developing a deep understanding of the concepts they are learning with teachers as the facilitators of this process. In order for this shift in mathematics education to be successful, teachers need to make this change in mindset as well and this can be extremely difficult. My study reveals that professional development can have a significant impact on how teachers implement manipulatives in the classroom. The teachers value opportunities to learn and actively participate in professional development where they can explore how to use manipulatives meaningfully in their practice. There needs to be a support system in place where there is “…the identification of ways to encourage and help teachers to make significant changes in their beliefs is very important because these beliefs will contribute to the success or failure of any changes made to their teaching practices that are consistent with the math curriculum reform” (Golafshani, 2013, p. 141). More specifically, if there were ways to help teachers identify their own possible misconceptions related to the implementation of manipulatives we could perhaps help teachers transform their practice so that it would be more aligned with a curriculum reform that promotes the deepest levels of thinking and reasoning through the proper implementation of manipulatives.

Recommendations
The following list provides recommendations based on the findings of my research that are beneficial for educators, school administrators and consultants:

1. Provide more resources for teachers regarding effective instructional strategies for implementing and using manipulatives.
2. Provide professional workshops that, based on the latest research, promote and encourage the effective use of manipulatives in mathematics.
3. Provides opportunities for educators to meet and share insights about how they use manipulatives in their practice.
4. Use of reflective practices to identify and explore teachers’ own practices and underlying beliefs in order to make changes and improve on teaching strategies.

**Limitations**

I acknowledge there are several limitations in my research project. To start, since this research consists of only three interviews with teachers whom all teach different grades in two different school boards, the findings may not be generalized to the teaching community. A larger sample size of the population would be needed to ensure a more accurate report of the experiences teachers’ have regarding teaching mathematics with manipulatives. The sample size should be more representative of pre-service teachers as well as female teachers. However, this study does provide the reader with insights related to the experiences of these three teachers which may be helpful to other researchers or educators who are working with manipulatives in mathematics classrooms.

The time constraint is another limitation on this research project. Given the parameters of two years to complete the study, there was only a certain range of activities that could be done. It
forces me, the researcher, to think of what can be done within this time frame instead of what could or needs to be done for the study.

Further Study

During the interviews with my participants, the topic of virtual manipulatives came up several times. I choose not to focus on virtual manipulatives in my research study because I felt like it touched upon many additional variables such as the availability and use of technology in the classroom as well as the impact of technology on student learning. This was not the main focus of my study, but I do feel that virtual manipulatives should be explored furthered given the expansion of the use of technology in the classroom. Additional research on how students perceive the role of manipulatives in their learning may help improve how teachers infuse manipulatives in their lessons. It may also be beneficial to explore how parent perceptions of manipulatives may influence students’ perceptions and use of manipulatives.
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Appendix A

Research questions

Participant background

A) How many years of teaching experience do you have?
B) What grade are you teaching at the moment? And have taught in the past?
C) What do you think math manipulatives are? How would you define them?

1) When you were a student, did you use manipulatives? And how did you use them? What subjects did you use them in?
2) During teacher’s college, what did your instructors teach you about manipulatives?
3) Have you attended any professional development courses regarding math manipulatives?
4) What do you feel the role of math manipulatives play in the teaching and learning process of math?
5) When do you use manipulative’s in your lessons?
6) What kinds of math manipulative’s do you use? Which ones are the most/least effective?
7) How do you know if the use of manipulatives have been successful?
8) Which strand of the math curriculum do you use manipulatives the most? And why?
9) How do you feel personally about math manipulatives in the classroom?
10) Does your team lead/administrator suggest/promote the use of math manipulatives?
11) How do students respond when you tell them they are going to use manipulatives?
12) Do you have any challenges in integrating manipulative’s into your lesson?
13) What kind of resources have you used to inform you about manipulative use?

Appendix B
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 student. I am studying math manipulatives for the purposes of a graduate research paper. I think that your knowledge and experience will provide insights into this topic.

I am writing a report on this topic as a requirement of the Master of Teaching Program. My supervisor is providing support for this assignment this year is 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 minute interview that will be audio-recorded. I would be grateful if you would allow me to interview you at a place and time convenient to you, outside of school time.

The contents of this interview will be used for my research project, which will include a final paper, as well as informal presentations to my classmates and/or potentially at a research 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 audio 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,

Researcher name: Anna Tran
Phone number, email: ____________, annatran.1423@gmail.com

Instructor’s Name: Cathy Marks Krpan
Phone number, email: ____________, cathy.marks.krpan@utoronto.ca