HOW DOES JOB-EMBEDDED TEACHER DEVELOPMENT INFLUENCE PRESCHOOL CHILDREN’S EXPERIENCE OF MATHEMATICS?

by

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Abstract

This action-based, qualitative research project involving 7 early childhood educators working in a well-established preschool child care program examined the influences of job-embedded professional development on children’s experiences of mathematics. Data was collected through observations, journals, conversations, interviews, and surveys, and then analyzed using a grounded theory model. A number of themes emerged, the strongest being those related to teachers’ increased awareness, interpretation, and support of children’s explorations in mathematics during play. This project provides an example of a successful model of teacher development for early childhood educators, and contributes to the growing field of research in mathematics education related to teacher noticing, but at the preschool level. Further, with the introduction of full day kindergarten and the emphasis on play based learning this project provides many rich examples of the mathematics present in children’s every day play that can be used in future teacher development.
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Also, Dr. Juanita Copley whose passion for teaching mathematics to young children I caught after hearing her speak a few years ago! Deep gratitude to Dr. Doug Clements and Dr. Julie Samara for “the blue book” and “the green book” that are, to me, the well-used and much loved “cookbooks” that help me understand the joy and the complexity of children’s mathematical development. Eternal gratitude for your dedication, time and expertise in this important work. I very much look forward to embracing breadth and depth as I continue my studies.

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Chapter One
Introduction

Background to My Research Interest

While it is quite possible to trace the path of my research interest for this thesis, to me it still remains somewhat unexpected...a reality I suspect is not all that uncommon in the field of research.

Professionally, I consider myself an experienced and seasoned Early Childhood Educator. For many years I have worked for a child care organization where I have filled the roles from infant teacher to program supervisor. The approach I bring to my work, and this research project, is a result of the intriguing, ongoing, and reflective interweaving of front line work, and years of studies in education. Through the latter I have been exposed to, and influenced by, the work of leaders in my field. These include Jean Piaget, Lev Vygotsky, Vivian Paley, and Lillian Katz, to name a few.

As a teacher of very young children, I have see myself as a facilitator helping children make sense of the world around them. Accordingly, I believe that skilled practitioners can support children’s development through a play-based curriculum that builds on their interests, includes both child-directed and teacher-directed activities, and encompasses all developmental domains. However, I acknowledge that I have not always given equal attention to all areas of programming. Throughout my undergraduate studies my interest was on children’s early literacy experiences, and was in fact the topic of my undergraduate thesis. I would go to great lengths to support children’s early development in language and literacy.
Admittedly, I have come to realize that I did not bring the same intentionality to children’s early mathematical development.

Notably, the shift in my attention began when I was accepted into teachers’ college and found myself in a math class for the first time since high school, many years ago. I had never considered myself particularly mathematical, however, this self-assessment soon changed. The professor of the Primary/Junior Mathematics class brought a fresh, new perspective and provoked students to reflect on their personal histories with mathematics, and the resulting attitudes and dispositions towards the subject. So it began....

While I was growing up, my father was a highly skilled, self-employed carpenter and cabinetmaker, and my mother was a talented dressmaker and knitter. I suspect they were deeply involved in design, on a daily basis, using mathematics without being aware of it. In our home there was always something being created. At a young age I followed my mother’s interest in knitting, and in my teens was knitting custom orders and dabbling in design. It was not until the math class in teacher’s college that I began to identify the areas of mathematics involved in creating a garment. Knitters count stitches, make estimations, perform operations such as addition, subtraction, multiplication and division. They are required to measure, and often have to identify the core of patterns to be repeated throughout a garment. They engage in two- and three-dimensional geometry when paying attention to proportionality. Creating symmetry in a garment, it is often necessary to use rotations, translations and reflections, an area of geometry called isometry. Interestingly, across cultures it is common for the mathematics in which women engage while carrying out such domestic work such as cooking, sewing, knitting, weaving, beading and other crafts to go unrecognized, by both women and men, as being mathematics (McLean, 2002, p. 184).
While still in teachers’ college I began to “notice” (Sherin, Jacobs, & Phillip, 2011, p. 3) mathematics everywhere. I read books about the culture and history of mathematics which, interestingly is a topic we rarely teach students. Upon graduating I worked as an assistant on a number of research projects related to teacher improvement at the level of elementary school mathematics. In the classroom observations I saw students struggle with basic mathematical concepts, and I increasingly began to wonder about children’s very early experiences of mathematics. Accordingly, I considered their early experiences of exploring the world around them, the objects they played with, and their early exposure to the language of mathematics. Indeed, one could say I began to make children’s early mathematical development my business.

Before long I decided to pursue studies at the graduate level and was accepted into the department of Curriculum, Teaching and Learning (CTL) at the Ontario Institute for Studies in Education at the University of Toronto (OISE/UT). I successfully completed a number of courses related to teaching mathematics at the elementary level and my interest continued to deepen.

Significantly, my research into children’s early experiences in mathematics was coinciding with emerging global attention to student achievement in mathematics (for example, Clements & Samara, 2008; Clements, Samara, & Liu, 2004; Ginsburg & Amit, 2008, Samara & Clements, 2009). Further, there is growing evidence that, across cultures, humans are born with a propensity to use mathematics to function effectively in their environment. In light of this, research has begun to focus on young children’s mathematical abilities and to move away from Piaget’s attention to children’s cognitive deficits.
Increasingly children are viewed as competent and capable beings who can and do engage in powerful mathematics (Clements & Samara, 2008; Copley, 1998; Seo & Ginsburg, 2004).

As I poured through the literature I discovered that my inattention to children’s early exploration in mathematics was far from unique among early childhood educators. I discovered bodies of research that included the topics of math phobia among primary teachers (Copley, 2004; Samara & DiBiase, 2004), teachers’ mathematical dispositions, levels of confidence and related issues of efficacy. Significantly, it appeared that a common theme in the research was the challenge of accessing effective and relevant professional development. To this end, and, as part of my graduate work, I began to develop workshops on early mathematics for early childhood educators and Kindergarten/Primary teachers. Word spread and I began to present workshops both at the local (for example, Four Counties Conference) and the Provincial level, (for example, Ontario Association for Math Educators [OAME] and Early Years Education of Ontario [EYEON]). My passion for this domain of children’s development was clear and it only made sense to make this the topic of my thesis. My research focus became an examination of how job embedded teacher development influences children experiences of mathematics.

During the project I witnessed profound incidents of learning by children and their teachers which in turn became deep and powerful learning for me. furthermore, the global interest in student achievement in mathematics remains strong and vibrant with countless emerging research interests. Governments in a number of countries, including Canada, the United States, Australia, New Zealand, England and Ireland have developed educational programs to support children’s early development in mathematics. Many of these programs include parental involvement. Without a doubt this continues to be an exciting field of
research and I am fully cognizant that my exploration of this topic is far from over. To this end I hope to continue my research at the doctorate level.

**Context for This Research Project**

The model I developed and implemented throughout this project was informed by current and existing international research in the area professional development for early childhood educators and primary teachers. Guided by best practices in this field, and over a number of years, I have presented workshops on the topic of mathematics in early childhood at conferences and for organizations. In turn these were evaluated, refined and eventually used in the design and implementation of this research project.

Firstly, I believe it important to summarize my personal view of the context in which my research took place. My understanding has developed over the 30 years I have been in the field of Early Childhood education in Ontario as a front line staff, advocate for quality child care, student, parent and researcher. During this time, I attended numerous conferences, been a member of advocacy groups, taken part in campaigns and lobbies for child care, and was enrolled as a student of education. These experiences contributed to my personal impression of the landscape in which this project took place.

In this province and, indeed, across North America there is a clear distinction between child care and education (McDill & Natriello, 1999). This distinction exists in the political, economic, institutional and professional arenas. It is beyond the scope of this paper to describe in detail the history of this distinction, however, the issues surrounding this reality permeate this paper and are worth noting.
Education has broad public support, and is seen as a fundamental right for children. In contrast, child care is seeped in societal values regarding the care of young children. Many view the issue of non-parental/guardian care as a personal choice reflected in such statements as, “You had them, you look after them. My taxes are not going to pay for your child care”. At the political level this view is further perpetuated in such government initiatives as the provision of vouchers for parents to use towards the cost of the “care of their choosing” rather than investing public funds into a child care system. Here the parent is viewed as “citizen” and not the child and what is in their best interests. This model, in fact, limits real choice and has resulted in an inadequate, underfunded, haphazard, and patchwork system of services.

Education is regulated by the Ministry of Education. Until January 2012 child care has been regulated by first the Ministry of Community and Social Services and then the Ministry of Children and Youth Services following Day Nurseries Act legislation (R.R.O. 1990, Regulation 262). As of January 2012, the Ministry of Education is mandated to monitor and regulate day nurseries under the Day Nurseries Act (R.R.O. 1990, Regulation 262) (www.e-laws.gov.on.ca/html/regs/english/elaws_regs_900262_e.htm)

Government funding for a school aged child is considerably more than that for a preschool aged child. For example, government spending for public education per child is approximately $6,000 per child per year (Ontario Ministry of Education, 2011). In contrast parents/guardians pay for child care and preschool programs themselves unless they qualify for a fee subsidy. A portion of child care expenses
can be deducted from annual taxable income (Canada Revenue Agency, 2012). The Ontario Child Benefit is income based for those earning under $30,000 and pays up to $1,100 per year for each child under 18 years of age (Ontario Ministry of Finance, 2012). Other sources of funding for young children exist in health care, for example, but are often for targeted populations.

☐ Schools provide child care and children are educated in good child care programs. These facts are rarely noted except school is not available because of teacher strikes, inclement weather, and holidays. Further, parents of young children seek out before and after school care because their children are too young to be at home alone while their parents work. Equally the educational component of quality child care programs is rarely acknowledged by anyone other than the teachers, and some parents.

☐ Significantly higher levels of education are required to teach in the school system (BA and professional BEd) compared to a 2-year diploma from a community college, or less, required to work in a child care program. Teachers are financially compensated at a significantly higher rate than ECEs who are among the lowest paid professionals. A number of Provincial Colleges and Universities are offering degrees, including at the doctoral level, in Early Childhood Education (for example, Lambton College, University of Toronto, York University) Some institutions offer degree ‘bundles’ that include an ECE diploma, BA and BEd. Unfortunately staff employed in the child care field struggle to afford to pay the tuition to further their education.
Public perception is that teachers educate and ECEs babysit. This attitude permeates teacher identity. ECEs often refer to themselves as “child care workers” and not as teachers or educators. They often undermine the value of their work by qualifiers such as “just being a child care worker”. ECEs report feeling undervalued as professionals compared to teachers in the school system. It is hoped that this will change with the development of the professional College of ECEs (C.E.C.E.) (http://collegeofece.on.ca/Pages/default.aspx) and the required registration to work in the field. Registered early childhood educators can officially use the letters R.E.C.E. as evidence of their qualification and membership in the College of Early Childhood Educators (C.E.C.E.).

Most child care programs have little or no funds available for professional development. This fact determines, for example, the availability, location, quality of speakers, and the duration of the session.

In 2007 Ontario released the Early Learning for Every Child Today (ELECT) also referred to as the Early Learning Framework (ELF) a development tool which may eventually be required to be used in programming in child care environments (www.children.gov.on.ca/htdocs/English/topics/earlychildhood/early_learning_for_every_child_today.aspx)

In 2010 the Province of Ontario introduced full day Kindergarten to be fully implemented in all schools by the year 2015 following a few years of gradual implementation (www.edu.gov.on.ca/kindergarten/) (Ministry of Education, 2010). The model places ECEs, for the first time, in classrooms along side
primary teachers. This may change opportunities for professional development, alter public perception of ECEs, and indeed influence ECEs’ professional identity.

The introduction of full day learning in Ontario for all children, and related concern for the future of child care programs, the introduction of the Early Learning Framework (ELF) and regulation of day Nurseries turned over to the Ministry of Education has provoked some ECEs to re-evaluate their roles in the education of young children. Most feel comfortable and competent in addressing language and literacy curriculum, but some have feeling less capable in addressing mathematics in early learning and care environments. This emerging interest is in alignment with a global interest in children’s performance in mathematics at all levels of education.
Chapter Two
Review of Literature

The particular nature of this project necessitated research into a number of areas related to children’s experiences of mathematics. These areas include the importance of mathematics, early childhood educators’ attitudes towards the subject, professional development for early childhood educators in mathematics and children’s early development in and experiences of mathematics. The findings from this research are described in this section.

Why Math?

In recent years the landscape of the education and care of young children in Ontario has evolved, and continues to do so. Factors in this change include the creation of a professional College of Early Childhood Education (C.E.C.E.), the introduction of full day, every day, Kindergarten in Ontario in 2010, the related concern for the erosion of centre-based, regulated child care, the introduction of the Early Learning Framework (ELF), and regulation of day nurseries mandated to the Ministry of Education. Consequently, it is perhaps not surprising that many early childhood educators are re-evaluating their roles in the education of young children. Most feel comfortable and competent in addressing language and literacy curriculum, but many feel less confident and capable in addressing mathematics in early learning and care environments (Copley, 2004; LeFevre et al., 2009; Samara & Clements, 2009; Skipper & Collins, 2003). Recent professional publications, alone, point to a growing interest in children’s early development in mathematics that aligns with the global
attention to children’s mathematical development and performance in mathematics at all levels of education.

Unprecedented advances in neuroscience, through such technologies as computer imagining (Bruer, 1999, as cited in Fox, 2007; Zambo & Zambo, 2008) have expanded our collective understanding of human cognition, and consequently, reinforced the importance of early brain development. Specifically, findings through neuroscience have confirmed the connections between children’s early experiences and their achievements in later life (Bruer, 1999, as cited in Fox, 2007, p. 866). In turn, this knowledge informs the increasing attention to student achievement in mathematics. Interest has included how children learn math, measuring and assessing mathematical development (Clements, et. al, 2008), and improving student achievement through teacher training (Bobis, 2005; Copley, 1998; Ginsburg & Ertle, 2008; Hill, Rowan, & Ball, 2005; Samara & Clements, 2009). Research demonstrates that, for a number of reasons, often related to economics and culture, children enter school with diverse experiences and differing levels of knowledge in all curriculum areas (Bobis, 2005; Clarke, Clarke, & Cheeseman, 2006; Griffin, Case, & Siegler, 1994; Jordan, Kaplan, Olah, & Locuniak, 2006; Jordan, Huttenlocher, & Levine, 1992; Jordan & Levine, 2009; Pappas, Ginsburg, & Jiang, 2003; Starkey, Klein, & Wakeley, 2004; Stipek & Ryan, 1997).

Subsequently, this has been termed a knowledge gap that continues to widen as children proceed through school. One variable that can be altered to improve student outcomes is the quality of the classroom learning environment (Brown, Molfese, & Molfese, 2008; Waxman & Huang, 1997, as cited in Varol & Farran, 2006). Notably, the effects of social disadvantage can be addressed through quality early intervention (Brown, Molfese, & Molfese, 2008; Sylva et al., 2006, as cited in Siraj-Blatchford, Taggart, Sylva, Sammons, & Melhuish, 2008;
Bobis, 2005; Meade, 2000 as cited in Fox 2007, p. 866). Indeed, the connections between early childhood development and economic and social growth (Aubrey, 2004; Dodge, 2004, as cited in Fox, 2007; Jordan & Levine, 2009) are well documented, and policy makers, for example the Organization for Economic Co-operation and Development (OECD, 2001,) identifies education as an equity and social justice issue, stating that equitable access to quality early education and care can strengthen the foundations of life long learning for all children (OECD, 2001). Furthermore, it is well recognized that mathematics is being applied to diverse fields (Myers, 2007; Steen, 2001 as cited in Fox, 2007; Varol & Farran, 2006), and those who understand math will have more opportunities than those who do not (OECD, 2001, p. 7). For these reasons, and more, experts are unanimous in recommending that children be exposed to math in their early lives (Samara & Clements, 2008; Sherman-LeVos, 2010; Varol & Farran, 2006, p. 381).

Correspondingly, internationally, many governments are developing policies and committing funds to support early numeracy development, for example, Australia (Doig, McCrae, & Rowe, 2003), New Zealand (Bobis et al., 2005), Great Britain (Aubrey, 2004, p. 650). Ontario (Ontario Ministry of Education, 2003) and British Columbia (British Columbia Ministry of Education, 2004) are two examples of how provinces are addressing early numeracy. Significantly, in North America, two leading professional organizations, the National Council of Teachers of Mathematics (NCTM), and the National Association of the Education of Young Children (NAEYC) have collaborated to issue a position statement that strongly advocates the teaching of mathematics to young children (Ginsburg & Amit, 2008, p. 274; Brown, Molfese, & Molfese, 2008, p. 107). The NCTM states that “high-quality, challenging and accessible mathematics education for 3 to 6 year-old children is a vital
foundation for future mathematics learning. In every childhood setting children should experience effective, research-based curriculum and teaching practices” (NCTM, 2002, p. 1). Further, the NCTM has developed a standards based framework for guiding young children’s experiences in mathematics which is informing curriculum development and teaching practices. However, Gifford (2004) notes that most of the research attention has focused on children’s competencies in mathematics with little attention to the pedagogy that can support children’s learning (p. 100).

**What Do We Know About ECEs and Math?**

While it is beyond the scope of this thesis it is, however, important to first acknowledge the long and somewhat complex history of “dumbing down” academic expectations for preschool children, particularly in North America (Balfanz, 1999; Lee & Ginsburg, 2009, p. 37). Traditionally, in most Early Childhood Education environments, there has been a demonstrated emphasis on supporting children’s social and emotional development and less on academics as an outcome (Kowalski, Pretti-Frontczak, & Johnson, 2001). Given the lack of regulated child care parents are often just grateful to have care, content to leave academics until their child enters formal schooling, thus placing few expectations on early childhood educators other than the provision of a safe, loving environment. Interestingly, when incidents of learning are made visible there are viewed by many parents as pleasant, but somewhat unanticipated outcomes rather than a fundamental expectation. While social and emotional development are critical to healthy child development, Kirova and Bhargava (2009) are among many experts who identify that in the early years provisions need to be made for both social and emotional and academic development (p. 4).
In recent years there is increasing evidence of a shift in the approach to the care and education of young children. The widespread influence of such pedagogy as that of Reggio Emilio encourage us to see children as capable and competent, focusing on abilities rather than deficits, for example, Piaget’s models of cognitive development (Gifford, 2004, p. 99; LeFevre et al., 2000). These factors, among others, contribute to the growing commitment among practitioners to provide children with curriculum that is more intentional and purposeful. This is already happening in approaches to language and literacy, an area where teachers typically have high comfort levels (Copley, 2004; Gifford, 2004; Samara & Clements, 2009). In addition, there have also been many public campaigns, aimed primarily at parents, that heighten awareness of the importance of early literacy experiences, such as reading to children. However, significantly less attention has been paid to children’s early mathematical development (Munn & Schaffer, 1993 as cited in Gifford, 2004, p. 100).

In North America, there exists a socially acceptable aversion to mathematics with such terms such as “math anxiety” and “math phobia”. Indeed, it is quite common to hear the expression “I don’t do math” whereas stating “I don’t read” carries the enormous social stigma of being illiterate. North Americans tend to see math as a choice, and not as a need or a right. Furthermore, in North America, mathematics has traditionally been taught as a set of procedures and skills with an emphasis on “getting the correct answer first” (Myers, 2007, p. 696) with little attention to mathematical concepts, and such things as the purpose and history of mathematics as a human activity. For many this approach has resulted in a negativity towards math and to dropping the subject at the very first opportunity.

Moreover, in the field of teacher education there is speculation that individuals make decisions around the level at which they would like to teach based on their comfort level with
the required mathematics and science curriculum (Ginsburg & Ertle, 2008). As far as early
colorhood educators there may be the perception that there is no requirement to “do” math at
all (Gifford, 2004, p. 99; Lee & Ginsburg, 2007a, 2007b, 2009). Perhaps for this reason early
colorhood educators tend to be more resistant than kindergarten teachers where there is an
expectation to teach mathematics (Ginsburg et al., 2006, as cited in Cross, Woods, &
Schweingruber, 2009, pp. 8–16; Copley, 2004, p. 403). Many feel incompetent, or even
fearful, about math and avoid planning activities (Henderson & Rodrigues, 2008; Le Fevre et
al., 2009; Skipper & Collins, 2003). Notably, even teachers who state they believe math to be
important do not practice this (Steven & Wilkinson, 1999, as cited in Gifford, 2004, p. 100;
Munn & Schaffer, 1993, as cited in Gifford, 2004). For these reasons, it is not surprising that
math is rarely the primary focus of a planned activity in preschool.

Indeed, as Gifford (2004) cogently states, “The problem of ‘teaching mathematics’ to
pre-schoolers is compounded by the lack of clear guidance as to what that might look like,
even if practitioners were prepared to do it” (p. 100).

Finally, it should be noted that our collective understanding of educational
environments is a result of examinations of both external and internal characteristics (Varol
& Faran, 2006, p. 382). External characteristics include such things as the physical space and
available materials (Varol & Faran, 2006, p. 382), and while materials are significant they do
not necessarily create effective learning environments (Varol & Faran, 2006, p. 382).
However, internal characteristics are very powerful in shaping classroom practices (Graham,
Nash, & Paul, 1997; Stipek, Givvne, Salmon, & MacGyvers, 2001, as cited in Cross et al.,
2009, p. 8), and include such factors as the personal qualities of teachers including their
beliefs, attitudes toward mathematics, attitude toward students, and his/her knowledge of
mathematics. Accordingly, these characteristics are significant in shaping how children experience early education and care environments. Clearly, one way to influence children's experiences is through professional development of educators.

**Existing Professional Development Opportunities for ECEs**

In researching professional development opportunities for early childhood educators it immediately became apparent that there was little to no information regarding this subject. In the three decades that I have been involved in the child care sector as an advocate, practitioner and parent, I can state with confidence that the effort to provide affordable, not-for-profit, quality, regulated child care for young children in this Province has had a tumultuous history influenced by, and vulnerable to, everything from World Wars to economics. The issues of child care routinely surface in the pendulous, 4-year cycle of election platforms and promises and government priorities. This fragility has often necessitated the leaders in the field of Early Childhood Education to expend vast amounts of time and energy in mobilizing staff and parents into public advocacy to protect existing programs from the latest round of government funding cuts. Historically, a lack of adequate funding in the regulated, not-for-profit sector has resulted in low staff salaries, whereby teachers are in effect subsidizing the system. There is reluctance to raise fees for fear of forcing parents to turn to unregulated care. This results in an increasing requirement to fundraise for program essentials. These facts frequently result in little investment into curriculum-related teacher development.

Nevertheless, it is safe to say that professional development opportunities do exist. Not surprisingly though, the ability to access these opportunities tends to reflect the
economic and systemic realities of the field itself. For example, the most notable provincial conference for early childhood educators is hosted annually by the Ontario Association for Early Childhood Educators (AECEO). It is held in a selected Ontario city with facilitators offering workshops on a range of topics. However, many programs struggle to fund staff to attend large conferences, having to pay for conference fees, travel, accommodations, and also cover the cost of replacing staff who wish to attend. Certainly, these reasons also make it cost prohibitive to sponsor staff to attend conferences offered nationally and internationally.

Ultimately, this leaves teacher development that is offered at the local level, either through small conferences and workshops, or through the workplace itself. Conferences, sponsored by local chapters of the AECEO, or community service providers are often offered on an evening or weekend. In some communities professional networks have been set up each pertaining to, either particular age groups, or curriculum areas. Larger-scaled programs, such as municipally run child care programs, or programs within the Community College system, tend to provide in-house training for their staff or sponsor attendance at sector specific conferences. There is little, if no, formal evaluation process or tracking of delegates to determine how any of this professional development actually influences children’s experiences.

**Effective Features of Professional Development in Mathematics**

A number of leaders in the field of mathematics education, for example, Clarke and Clarke (2005), Copley (2004), Gifford (2004), Hill (2004), Hill et al. (2005), Lee and Ginsburg (2007a, 2007b, 2009), Samara and Clements (2009), and Skipper and Collins (2003) have contributed to a body of research that identifies best practices in teacher
development in mathematics. A critical examination of their work was undertaken to inform this project.

Professional development can be described simply as the improvement of teacher practice leading to better experiences for children. Experts agree that, first and foremost, professional development should reflect sound practices in adult learning and be tailored to fit a particular cohort (Cross et al., 2009, pp. 8–19). Samara and Clements (2009) and Skipper and Collins (2003) stress that professional development must be sensitive to teachers’ perceived needs and priorities, and respond to each individual’s background, experiences and current context or role (Jacobs, Lamb, Phillipp, & Schappelle, 2011, pp. 112, 201; Samara & Clements, 2009). Further, research shows that teacher confidence increases, and attitudes towards mathematics become more positive when experts listen to teachers’ perspectives, and connect ideas to teachers’ experiences (Hill, 2004, p. 221, Samara & DiBiase, 2004, p. 419).

Samara and Clements (2009) elaborate by describing specific aspects of effective professional development in mathematics which are worth noting. According to Samara and Clements (2009) professional development experiences should be stable, of high quality and include observation, experimentation, and mentoring with adequate time for reflection (pp. 347–365.). Furthermore, professional development should be grounded in a sound theoretical base and use curriculum materials that focus on children’s math thinking and learning (Samara & Clements, 2009, pp. 347–365). Similarly, Hill (2004) concurs that professional development is more effective when it is supported over time and embedded in a system of assessments and curriculum that support learning (p. 217). Additionally, successful teacher development focuses on content, and is grounded in artifacts of practices such as curriculum,
videotape or student work (Hill, 2004, p. 217). Moreover, Varol and Faran (2006) remind us that teachers often need pedagogical guidance in the use of such things as appropriate mathematical tools or manipulatives, the selection of tasks and modeling of communication or discourse around mathematics in the classroom (p. 382).

Significantly, experts acknowledge the importance of the social context of professional development, and purport that teachers must have time to learn and work with colleagues, especially a consistent group (Clarke & Clarke, 2005; Clements, 2008; Copley, 2004). This recommendation aligns with the term “communities of discourse” which refers to learning environments, both in the classroom with students, and in professional development for teachers, where discussions around mathematics take place. Accordingly, Putman and Borko (2000, as cited in Copley, 2004, p. 413) identify communities of discourse as effective vehicles for teacher change. Within these communities teachers can discuss research-based knowledge, reflect on teaching practice and share student learning experiences. Moreover, Copley (2004) concurs that when teachers’ ideas are meshed with research-based knowledge effective teacher change can occur (pp. 401–414).

Of significance to this project is the agreement among experts regarding the importance of sustained and ongoing teacher development (Cross et al., 2009; Jacobs, Lamb, Phillipp & Schappelle, 2011, p. 112; Samara & Clements, 2009), “since it has been demonstrated that the effects of content specific professional development fade over time teachers need professional development opportunities throughout their careers” (Cross et al., 2009, pp. 8–19). Specifically, Samara and Clements (2009) make reference to ongoing, job-embedded teacher development (pp. 347–365) which has informed this project.
When we turn our attention to professional development specifically for early childhood educators we cannot hope to change practices without first addressing teachers’ fundamental beliefs about their role as educators (Lee & Ginsburg, 2007b; Ryan, 2004, as cited in Cross et al., 2009, p. 8). Given the history of math avoidance in the Early Childhood Education community the first objective in teacher development is to encourage teachers to adopt the belief that math does belong in the preschool curriculum. Accordingly, Varol and Faran (2006) emphasize that when this occurs the classroom transforms into a learning environment that advances students’ mathematical abilities (p. 382).

Secondly, training must focus on teachers noticing the math that children are already doing. Undoubtedly, teachers need to be made aware of the math embedded in everyday activities (Skipper & Collins, 2003). Specifically, teachers need to first recognize children’s demonstrated understanding of math concepts, possess the mathematical language to guide them from behavioral to representational understanding (Skipper & Collins, 2003). Indeed, teacher noticing is an emerging field of research in elementary school mathematics and is described as follows,

To manage the complexity of the classroom, teachers must pay attention to some things and not to others. In other words they must choose where to focus their attention and for how long and where their attention is needed and not needed and again for how long. (Sherin, Jacobs, & Philipp, 2011, p. 5)

Jacobs, Lamb, Phillipp and Schappelle (2011) claim that is is possible, through teacher development, to improve teacher noticing skills (p. 112). This professional noticing of children’s mathematical thinking includes attending to children’s strategies, interpreting children’s strategies and deciding how to respond on the basis of children’s understandings (Jacobs et al., 2011, p. 99).
Thirdly, based on what they observe teachers can assess and interpret children’s understanding and thus plan intentional and developmentally appropriate curriculum. Interestingly, this process involves a spiral of looking, thinking and acting that transforms practitioners into researchers (Springer, 1999, as cited in Creswell, 2008, p. 604) with the potential for early childhood educators to see themselves as confident, capable, and effective math teachers.

Finally, much has been written about children’s literature as a comfortable starting, or entry point, for teaching mathematics. Further, “many children’s books present interesting problems and illustrate how other children solve them” (Ward, 2005, p. 134). “Literature motivates students to learn, provides a meaningful context for math, celebrates math as a language, demonstrates that math develops out of human experience, fosters the development of number sense, and integrates math into other curriculum areas” (Whiten & Wilde, 1992, 1995 as cited in Shatzer, 2008, p. 649). “Furthermore, mathematical activities stimulated by children’s literature can inspire students to more actively explore and investigate mathematical concepts while fostering the realization that mathematics is everywhere in the world around them” (Brandon et al., 1993, as cited in Ward, 2005, p. 134). Research shows that the illustrations in children’s picture books provide visualizations of mathematical concepts (Murphy, 1999, as cited in Shatzer, 2008, p. 650).

**Evaluating Professional Development**

It is well recognized that even the most exemplary professional development is rarely evaluated using rigorous designs and objective measures of teacher or student learning (Hill, 2004, p. 216). This makes it difficult to separate effective professional development from
ineffective professional development and often allows the latter to thrive (Hill, 2004, p. 217). One way to bring about change is to develop and implement well-designed evaluations of professional development based on outcome measures (Hill, 2004, p. 228). Indeed some standards have been developed through studies on exemplary professional development offered by universities (Hill, 2004, p. 216), however, these standards have never been studied to see if they can differentiate between good and bad professional development (Hill, 2004, p. 216). Indeed, there are examples of professional development that meet the standards but look mediocre when judged according to content, especially around student learning, and conversely other professional development that meets fewer standards yet offers richer opportunities for teachers to learn (Hill, 2004, p. 221).

In an extensive study on professional development researchers found cases where, in an attempt to cover many topics, the focus became superficial (Hill, 2004, p. 223). While other workshops served primarily as a forum for teachers to complain about state curriculum and testing (Hill, 2004, p. 224) while other findings included procedural math presented as conceptual (Hill, 2004, p. 227). Notably, much of the format involved going over rules and procedures about doing math rather than to discuss student learning, typical student errors and misconceptions, and instructional strategies to remedy these (Hill, 2004, p. 227). In one workshop teachers were observed colouring, cutting and pasting with little or no discussion about the mathematics involved in the activity (Hill, 2004, p. 227). Further, most professional development is still delivered through one-shot sessions that lead to discouraging results (Hill, 2004, p. 216; Copley, 2001, p. 101). This project will examine how a model of job imbedded professional development influences children's experiences of mathematics.
Childrens’ Mathematical Exploration

In this model of job-embedded professional development the researcher plays a number of roles. These include observer, co-observer, participant, role model, co-learner, teacher and mentor. The goal being that through working alongside the researcher the practitioners will come to notice children’s mathematics, interpret it and act on their new understandings. Through this job-embedded teacher development it is hoped that the confidence levels of the teachers will increase and lead to improved mathematical experiences for children. In order for the researcher to play this role successfully a broad and deep review of current research on children’s mathematical development and related curriculum was undertaken. This section is far from exclusive, but does provide a concise summary of the key mathematical explorations which may be observed in the project. A more detailed description of the developmental stages of children’s mathematical development has been included as an appendix (see Appendix G).

There is much evidence, from art to architecture, that humans, across cultures, are born with a foundational mathematical knowledge that includes such things as a fundamental sense of quantity (Geary, 1994, as cited in Samara & Clements, 2009) spatial reasoning, a propensity for patterns and a preference for closed shapes (Clements, 2009, p. ). According to Sarama and Clements (2009), children of all ages have some knowledge of mathematics (p. 68) including infants. Research over the past 25 years has shown that “nearly from birth to age 5, young children develop an everyday mathematics – including informal ideas of more and less, taking away, shape, size, location, pattern and position – that is surprisingly broad, complex, and sometimes sophisticated” (Ginsburg, Lee, & Boyd, 2008, p. 3; Samara & Clements, 2009, p. 16). Likewise, children show persistent interest in comparing heights of
different towers, of exploring and creating patterns, shapes and symmetry (Clements & Samara, 2008; Cross et al., 2009; Seo & Ginsburg, 2004, p. 93). Notably, Epstein (2003) reminds us that, “Math is more than numbers and rote counting. It includes preschoolers’ investigations into size, quantity, categorization, patterns, speed, and sequence” (p. 5).

Not surprisingly, much of this mathematical knowledge is developed through children’s natural curiosity (Epstein, 2003, p. 5) and interaction with their world through play. Notably, in a seminal study, Seo and Ginsburg (2004) analyzed video footage for mathematical content of 90 5-year-olds during free-play time. Each child in the study was taped for a 15-minute period. Results demonstrated that 79 of the 90 children (88%) engaged in at least one math activity during their play and that the average number of minutes in which math occurred was 43%. In other words, 7 of the 15 minutes were related to math. Evidently preschool and kindergarten children engage in a significant amount of math during free play. Further, they engage in a variety of types of math. Notably, they explore patterns, shapes, and compare magnitudes and enumerate with the exploration of dynamic changes, classifying and examining spatial relations occurring less frequently (Seo & Ginsburg, 2004). The researchers determined that the variables of income level and gender were not related to the overall frequency of math. Conversely, age was related to overall frequency of math activity with older children engaging in more math than younger. Moreover, exploration of pattern, shape and enumeration related to age, while other math concepts did not. Specifically, older children dealt with patterns, shape and enumeration to a slightly greater extent than did younger children. Seo and Ginsburg (2004) cogently summarize their findings, “The bottom line is that pre-school and kindergarten children’s mathematics is more advanced and powerful than is often realized, and that children from different income-
level groups display similar amounts, patterns, and complexities of mathematical behaviour” (Seo & Ginsburg, 2004, p. 103).

Ultimately, there is general agreement that children in their early childhood years develop an everyday mathematics (Ginsburg, Lee, & Boyd, 2008, p. 3) that is “an essential and even an inevitable feature of the child’s cognitive development, and like other aspects of the child’s cognition, such as theory of mind or critical thinking, develops in the ordinary environment, usually without direct instruction” (Ginsburg et al., 2008, p. 3). While children’s thinking related to mathematics may differ from adults, they use mathematical ideas in play, are curious about the subject, and are capable of learning interesting mathematics when taught (Ginsburg & Amit, 2008, p. 275). To this end, as educators we can view children’s actions and words as opportunities for adults to extend their thinking. Indeed, “The role of teachers and parents is to provide children with the appropriate words, materials, and resources to explore their interests and scaffold new levels of understanding” (Epstein, 2003, p. 5). The purpose of this project is examine and understand a model of teacher development that will ultimately lead to positive and enriched experiences for children in their early mathematical development.
Chapter Three
Methodology

Purpose of the Study

The purpose of the study is to improve and enrich young children’s experience of mathematics in their child care environment through job-embedded teacher development.

Research Questions

My research project was designed to answer the following questions:

☐ How does job-embedded teacher development influence the way children experience mathematics in a child care program?

☐ What kind of math do the children engage in most frequently in their everyday play?

☐ Under what social conditions do children most frequently explore mathematics, alone, in pairs, in a group?

☐ How do teachers notice and extend children’s explorations in mathematics?

☐ How is mathematics visible in the physical set up of the rooms?

☐ How is mathematics present in teacher-developed activities?

☐ What kinds of mathematics language is used by teachers with the children?

☐ Describe the dispositions teachers have towards children’s math?

☐ How do teachers offer feedback to parents regarding their child’s mathematical development?
Research Design

The design model best suited for this research project can be described as qualitative, action based research (Creswell, 2008, p. 397) with models of grounded theory informing the data collection and analysis process (Charmaz, 2008). Notably, action research tends to be democratic, participatory and emancipatory providing a theoretical framework through which to deeply explore and provide solutions for improvement of an identified issue (Stringer, 1999, as cited in Creswell, 2008, pp. 397, 603). In this case the issue is the enrichment of children’s experiences in mathematics through job-embedded teacher development (Stringer, 1999, as cited in Creswell, 2008, pp. 397, 603). Indeed, action research is well suited for research in education for it provides opportunities for educators to reflect on their practice, and closely examine issues that constrain and repress the lives of both students and educators (Creswell, 2008, pp. 397, 603). Creswell (2008) describes the key characteristics of action based research as having a practical focus, concerning the educator-researcher’s own practices, collaboration, dynamic process, a plan of action, and shared research (Creswell, 2008, p. 605). The model of grounded theory allows for the use of both inductive and abductive strategies for collecting and analyzing qualitative data (Charmaz, 2008, p. 168). In the grounded theory model there should be no preconceived ideas, the ordinary should be made problematic as taken for granted meanings are explored (Charmaz, 2008, p. 163). Throughout the project I aim to stay very close to the data, interact with it and try to make sense of it through comparing pieces of data with other pieces of data, ideas and incidents. Consequently, data collection will shape further data collection leading to the eventual coding process where identified categories synthesize the data. The result is that the emerging theories are directly grounded in the data (Charmaz, 2008, p. 168). “Grounded
theory fosters openness to what is happening in the empirical world” (Charmaz, 2008, p. 163). This means studying data and developing an analysis from conceptualizing data rather than imposing a theoretical framework on them. This theoretical model is ideal for observations of children as it respects the emergent nature of children’s play and the related guidance from the educators. It is likely that there will occur during the observations examples of teachable moments (Copley, Jones, & Dighe, 2007, as cited in Ginsburg et al., 2008, p. 4) involving mathematics that can be used make mathematics visible to the children and educators.

Further, from the beginning I negotiated my role in the research while striving for open, broad based involvement from participants who I considered equals in the research (Creswell, 2008, p. 603). An important aspect of the model was the attention I paid to making the teacher development personalized for each participant. I hoped that teachers would view the content of the project as meaningful and relevant to their situation and thus take ownership of their learning. We discussed the individual components of teacher development that I could provide, including, coaching the modeling of learning activities, assuming the role of playroom teacher thus enabling the participants to observe the children, and finding resources requested by participants. I placed an emphasis on helping to create a picture that helped stakeholders understand the issues they were experiencing (Springer, 1999, as cited in Creswell, 2008, p. 604). Springer describes this process as a spiral of looking, thinking and acting (Springer, 1999, as cited in Creswell, 2008, p. 604). The first stage involves looking and gathering data through interviews, observations, and documents. The findings are then reported to the stakeholders. The think phase involves interpreting the issues and identifying priorities for action (Creswell, 2008, p. 604). Then, in consultation
with the participants a plan of action and methods of evaluating any changes are developed. The identified issue is closely monitored to determine if the research has made a difference (Creswell, 2008, p. 613). A key component of action research is the timely sharing of research findings with the group so that they might be used for the group’s benefit (Creswell, 2008, p. 609).

The Project

This research project came about through an expressed interest from a group of practitioners working in a centre-based child care program who, as a result of the changing landscape of child care and early education described earlier, were re-evaluating their professional roles as educators and caregivers of young children. Collectively, they wished to become more intentional and confident in supporting children’s mathematics in their programs.

The project took place in the two preschool rooms of a large child care program in a small city in Central Ontario. The program is operated by a non-profit child care agency that has been providing child care in the community for almost four decades. The agency operates four sites and provides quality care for children aged from 6 weeks to 12 years of age. Enrollment options include full day, on a part-time or full time basis, and before and after school care. The research took place at a program located on a university campus. The program is licensed for 56 children, aged from 6 weeks to 6 years of age, and employs approximately 15 staff; a number that includes staff working with children with exceptionalities. While the child care program is open to the community at large, priority in
filling spaces is given to families who have an affiliation with the university, either as a students, staff or faculty.

After the project received approval from the Research Ethics Board of the University of Toronto (see Appendix A), permission to conduct the research at the proposed site was sought and granted by the Chairperson of the Board of Directors, the Executive Director of the Organization and the supervisor of the child care site (see Appendix B). A few weeks before the study began I presented information about the project to all staff working at the site. Further, information letters explaining the project were sent out to all families with children enrolled in the program (see Appendix C). It was deemed unnecessary to gain written permission from parents regarding their child(ren)’s participation in the project since the focus of the research was on teacher responses to children’s mathematical explorations during play and not on the children themselves.

The research took place over a period of 12 weeks from the beginning of April until the end of June. These dates were selected because they represented a time period of stable enrollment and staffing prior to children leaving the program for the summer. Further, during the summer attendance is noticeably more variable and this is typically when educators take vacation time.

The first room, the Junior Preschool room, is licensed for 16 children, aged 30 months to approximately 40 months, and is staffed with two full-time staff and two additional staff who are funded to work with children with special needs enrolled in the room. The second room, the Senior Preschool room, is licensed for 18 children, aged from 4 years to 6 years of age, and is staffed with two full-time staff and one additional staff
working with a child with special needs. A large number of children in the Senior Preschool room attend Junior and Senior Kindergarten on a part-time basis. All the preschool staff, a total of 7 teachers, were interested in participating in the project and provided their written consent to participate (see Appendix D). All participants were female and their ages ranged from mid-20s to early 60s. The participants’ years of experience in the field ranged from 2 to over 20 years. Five of the seven staff had Early Childhood Education diplomas, one had a BA in addition to the ECE, one had a BEd, but no ECE, and one had qualifications as a child and youth worker. Teacher qualifications are summarized in Table 1.

**Table 1**

*Teacher Qualifications*

<table>
<thead>
<tr>
<th>Teacher Qualifications</th>
<th>Number of Staff</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECE diploma only</td>
<td>5</td>
</tr>
<tr>
<td>ECE and BA</td>
<td>1</td>
</tr>
<tr>
<td>BEd no ECE</td>
<td>1</td>
</tr>
<tr>
<td>Other</td>
<td>1</td>
</tr>
</tbody>
</table>

Creswell (2008) reminds us that a priority in action research is to help participants understand their situation, and then develop a plan of action based on their self-identified needs. Specifically, the objectives of the researcher are to create a sense of trust between themselves and the participants. It is hoped, through co-operative relationships and good communication (Creswell, 2008, p. 608) to create a dynamic environment where the researcher spirals back and forth between reflection about a problem, data collection and action (Creswell, 2008, p. 609). In keeping with these objectives, a schedule of observations was developed in consultation with the staff. It was agreed that the observations were to be conducted every Thursday in the Junior room and every Wednesday in the Senior room. Shortly into the project the teachers in the Junior room requested to move the observations to
Tuesdays because of recently scheduled visits from other professionals on Thursdays. The teachers wished to limit the number of adults in the room on any given day because of how the children might be affected.

It is widely accepted that as soon as a decision is made to observe or study something it has already changed. In this case it is quite likely that as soon as the participants learned of the proposed research project they began to pay more attention to math. While this fact needs to be addressed the attention to math is consistent with the overall objectives of the project.

The project began with two observations, a week apart, of the two playrooms. The purpose of these observations was to determine the level of attention being paid to mathematics in the rooms prior to the more explicit influence from the project. The observations considered both the external and an internal aspects of the playroom cultures (Varol & Faran, 2006, p. 382). The external culture includes the actual physical set up of the room, including the selection of materials available for the children, and displays such as bulletin (Varol & Faran, 2006, p. 382). The internal environment refers to the interactions between teachers and children (Varol & Faran, 2006, p. 382). Of interest to this particular project are teacher attention to the mathematics in children’s play, teacher use of mathematical vocabulary and conversations about mathematics between children, between educators and children, and between educators.

Given the individual and emergent nature of young children’s understanding of mathematics these observations also served to form an overall sense of the level of development in each group, and to determine any areas of exploration and interest in mathematics among the children. Where possible and appropriate photographs of children
work were used to provide feedback and make mathematics more visible to children, staff and parents. Data from the observations was used for teacher development and to inform the planning of activities.

After the completion of the two observations in both playrooms, each teacher completed a short, confidential survey (see Appendix E) about their experiences and attitudes towards teaching, in general, and about mathematics, in particular. The purpose of the survey was to provide insight into teachers’ confidence levels and sense of efficacy. The surveys were numbered one through seven, and each teacher selected one at random. Teachers made note of the number and this became their confidential assigned number for the project. Then the teachers each selected a journal with their number on it. The purpose of the journal was to write questions, reflections and responses to the project. It was hoped that the journals would encourage teachers to conduct studies on themselves (Kemmis & Wilkinson, 1998, as cited in Crewswell, 2008, p. 603). Through the journals they could examine their practices and beliefs, and become more aware of how this knowledge shapes, and perhaps constrains, their work with children. Kemmis and Wilkinson (1998) describe spirals of action and reflection as teachers try a new action and then reflect on what they learned (Kemmis & Wilkinson, 1998, as cited in Creswell, 2008, p. 603). In addition, each teacher was given a binder to collect articles and information associated with the research.

Further, in keeping with the democratic and participatory values of action research (Creswell, 2008), I met with each educator individually to develop a research plan. Educators were offered the opportunity to observe the room on occasion while I assumed their role. As in most child care program schedules, time is allotted for large group activity, typically referred to in the field as “circle-time”. This is generally a teacher planned and directed part
of the daily schedule. In programs where the curriculum follows themes, circle time would provide opportunities to explore the current theme through such activities as sharing stories, singing songs, presenting science experiments, or baking with the children. In the program where the project took place the teachers selected themes based on the current interests of the children in the group. To this end the themes in the two preschool playrooms were often different from one another. In both of the rooms the children are divided into two groups for circle. This practice is followed for a number of reasons, including reducing congestion in the cloakroom as one group can dress for outdoors while the other group has circle and smaller group size reduces the amount of time children are required to wait for a turn at a circle activity. I believed that circle time would provide an ideal opportunity to present mathematical concepts to the children and model to the teachers how this could be done. In addition, to presenting circles, I offered to model other learning activities, bring in articles, and provide feedback about observations of children’s exploration of mathematics in their play. Two teachers requested the opportunity to observe the children themselves while the researcher took over their role as playroom teacher. Others indicated they would find it more beneficial to have researcher to model circles and art that had a math focus.

The next 16 planned observations took place on a weekly basis and consisted of a 1-hour observation of each playroom during morning free-play time. During the observations, I adopted what is referred to as a changing observational role where the researcher adapts their role depending on the situation (Creswell, 2008, p. 223). In some situations rich data can be collected by simply observing a situation unfold. In contrast in other situations it may be more appropriate to participate in the action, such as asking a child to explain their work, or drawing a staff’s attention to a child’s explorations. All observations
were conducted by myself, except for three which were completed by the two educators. In consultation with the educators, I spent the remainder of the mornings engaged in a variety of tasks, including modeling circles, introducing art activities, or sharing with participants, observations and photographs of student work.

In week 9, 3 weeks before the end of the project, I interviewed each teacher individually. In this process of data collection I posed a number of specific questions (see Appendix F) about the project specifically, and about the nature of their work in general. This was intended to gain understanding about the general context in which the project took place.

At the end of the project the teachers completed the second section of the survey. The teachers used their confidential identification number on the survey so that the initial survey and the final survey could be analyzed to identify any changes in individual teacher ratings.

In addition, towards the end of the project, I set up displays of age specific toys, books, equipment that supported children’s early mathematical development in the front foyer of the Centre. In addition, related hand outs and articles were available. Parents, children and staff were encouraged to interact with the materials.

At the end of the 12 weeks the text data was assembled from the following sources: teacher surveys, journals, field notes from 24 playroom observations, notes in the researcher’s field journal, conversations, transcripts from interviews and many photographs of the children’s work. The data was analyzed using text segment codes (Creswell, 2008, p. 251) which were then collapsed into a number of themes. As themes emerged the researcher reported and verified the findings with the participants in the process of member checking.
(Creswell, 2008, p. 266). The findings and the themes that emerged, some expected and others unexpected, are described in the next chapter.
Chapter 4
Results

Junior Preschool Room

Context

Based on the body of research regarding early childhood educators and primary teachers’ general neglect of mathematics it is perhaps somewhat predictable that the strongest theme, and the one which will be the main focus of the results was that of teachers beginning to notice children’s math. Clearly, noticing the math that children do naturally is a desirable and logical first step in improving the child’s experiences of mathematics, and provides evidence of the effectiveness of job-embedded professional development. Indeed, there was often an emotional and emancipatory nature to this discovery which led to deep and powerful learning for the children, teachers and the researcher.

The presentation of the results is organized around a number of significant moments of teacher noticing informed by the spiral of looking, thinking and acting. This approach is consistent with, and complimentary to, the emergent nature of children’s play and understanding, and is informed by Newman's (1987) work on critical incidents that lead to deep learning.

Critical incidents are those moments which allow you to stand back and examine your beliefs and your teaching critically. They are stories used as tools for conducting research on yourself. Critical incidents can be triggered in the midst of teaching, but they can occur in a variety of other ways. They can arise through reading, or overhearing a comment, or noticing how someone else is doing something you've always taken for granted, or suddenly seeing your own learning differently. (Newman, 1987, p. 727)
Newman (1987) asks us to consider the following questions: Why was an incident memorable? What made it significant? What did we learn from it? How might we have dealt with that situation differently? (pp. 727–737). These questions serve to guide teachers as they engage in reflective practice (Schön, 1987, as cited in Newman, 2000) that has been shown to improve student learning. In this section quotes from teachers are italicized while quotes form my research journal are in bold italicized font.

The Junior room is typically a very busy room with young children whose attention spans are relatively short. They are still developing many skills, such as language and cooperative play skills, impulse control and self-regulation. The educators are occupied with modeling desired behavior and ensuring children are safe. There are daily routines to follow which include, serving snack, assisting children with bathroom routines (typically several children would still be in diapers and others would be in the process of being toilet trained) greeting parents, taking messages, and supporting children with difficulty separating from parents/guardians.

I, as researcher, was not included in the child-staff ratios, and was present with the sole purpose of observing children’s mathematical explorations, a task for which educators on a typical day in a busy playroom simply do not have time. Further, many educators may not immediately recognize some of the children’s explorations as mathematical in nature.

**Math**

Observations of the classroom environment showed little attention to mathematics. On the posted daily activity sheet there were no explicit references to mathematics in the program, although one heading referred to cognitive toys. It was noted the equipment that
could be considered mathematical in nature included coloured foam blocks, puzzles and various cognitive toys. The teachers frequently used mathematical language to describe position and location. They compared the size and height of objects, modeled counting and made references to time such as announcing that, “in five minutes it will be time to tidy up”. There were a number of examples of children exploring mathematics alone and in pairs, for example, Zara and Edward working on a puzzle together (April 7, 2010). Interestingly, children often used equipment in unintended way to explore mathematics which will later be described in detail.

Critical Incident # 1
Anya at the playdough centre: photographs help teachers to begin to notice the math in children’s play

In the first observation, I approached the playdough table where Anya was working. Anya had rolled seven small balls (or to be mathematically correct, “spheres”) out of playdough and had them lined in a row. Spontaneously she began to count them. I watched carefully and discretely photographed the work. Anya touched each ball only once and said one number word for each ball. She said the number words in the correct order. She did not repeat or skip number words. She kept track of where she was and did not count a ball more than once or exclude a ball. She stopped counting when she reached the last ball and announced, “Seven!”

Anya then began to loosely pile the seven balls together to make a large pyramid and then proceeded to separate them back into seven separate balls. From this incident educators can determine that Anya has well developed cardinality to seven and perhaps beyond. As Anya manipulated the playdough creating balls, which she piled together and then pulled
apart again she demonstrated a flexibility in thinking, indeed, a habit of mind, that will provide a solid foundation on which to build future mathematical thinking. Eventually this fundamental approach to the playdough can be transferred to working with numbers which are made up of other numbers and can be pulled apart and put back together. In this activity Anya can be seen to be exploring whole units and fractions of a unit. She created a pyramid that was formed by putting the seven balls together. Each ball represented one seventh of the whole pyramid and Anya explored merging the seven balls and separating them again. In addition Anya was also exploring visual/spatial, volume and mass in the field of geometry as she worked with the material creating small spheres and forming them to make a pyramid. Further, Anya was learning about conservation the amount of clay remained the same regardless of whether it was in the form of seven small spheres of one large pyramid. She explored the material with great confidence and with a sense of curiosity and wonder. No one had asked her to do any of this....she was just playing.
The educators were intrigued with the photographs which documented Anya's exploration. The educators admitted that often when they observe a child occupied at a centre such as playdough they turn their attention to the situations where they feel they are ‘needed’. Jessica explained it like this in an interview, “I would just look over there and think, ok, she’s fine over there”.

The educators agreed that they would not immediately think of the playdough centre as a place where children would explore mathematics. Here I saw that my role as a researcher was to draw attention to the mathematics, guide the educators to think about it, interpret it and consider how to act next to support Anya’s development. I articulated that research has shown that children’s mathematical exploration can become more complex simply because
an adult is present, even if the adult does not actually engage with the child (Sylva et al., 1980, as cited in Gifford, 2004, p. 108).

**Supporting Teacher Development With Photographs of Children’s Work**

From the beginning of the project it became very clear that the use of photographs I was taking of the children’s mathematical exploration were, for a number of reasons a valuable tool for increasing the teachers awareness and interpretation of the mathematics in children’s everyday play. In terms of the research design this would be identified as the stages of looking and thinking. First, in a busy playroom the photos documented the children’s work to be studied by the educators at appropriate times. Second, the photos served as a way to share children’s work with all staff regardless of whether they actually observed the incident or were even present at the time. Third, the photographs served to make children’s mathematics visible to themselves, the educators and the parents.

Early in the project I shared photographs of children’s play which depicted a number of children deeply engaged with matching one set of objects to another set of objects. Often this involved using playroom materials in unconventional ways. For example, Anya placed wheels from a puzzle on her fingers and then one tire on each wheel of a puzzle (Junior Room Observation 7). On other occasions Anthony, Edward and Bronte (Junior Room Observation 6) placed stacking beads on their fingers until they had one bead on each finger. These incidents of children’s exploration of one to one correspondence provide evidence of an emerging understanding of the concept of number. Experts agree that this is preliminary to counting and includes conceptual understanding of equivalence and conservation of number (Charlesworth & Lind, 1999, as cited in Kirvova & Bhargava, 2009; Montague-Smitth, 1997,
as cited in Kirvova & Bhargava, 2009, p. 6). From this stage children come to understand that one number word can be matched with one object to determine the number of objects in a set (cardinality).

The photographs provoked rich discussions about the complexities of counting, and reflection about the children’s developmental stages and related interests. Participants agreed that most of the children in the group could recite the number words to 10 correctly, but had observed that when asked to actually count a set of objects “they just keep saying the numbers even after they run out of objects” (Mary, in conversation). Participants articulated that they were very interested in learning more about these misconceptions and were provided with articles about how children learn to count effectively. In discussing the effectiveness of photographs Emma stated in an interview,

*They highlighted the math by focusing in on one piece. We are not always able to see everything that is going on.*

**Critical Incident # 2**

**Anya and Shannon play a grid game: evidence of teacher noticing, reflecting, and acting**

From playroom observations, and discussions with the participants, we decided to make the focus in the Junior Room that of number sense with attention to accurate cardinality to three. In week 9 of the project I developed a circle to demonstrate a number of things: how to extend children’s understanding of number, children learning from each other and the fostering of pair and whole group conversations about mathematics (Sylva, 1984, as cited in Gifford, 2004, p. 107). I set up three centres related to three strands of mathematics. One consisted of tube shaped pasta coloured in three colours and string for creating necklaces
(patterning). At the second centre children explored the properties of three dimensional solids while creating structures (geometry). At the third centre I introduced a grid game (number sense). Two children worked at each centre and then returned to circle where they shared with their peers what they done. Two girls went to the grid game centre where Jessica assisted them in playing the game. Jessica made the following observation. She noted that Anya picked up a card with three dots and placed one jewel on each dot (matching one set of objects with another set in one- to- one correspondence) and when confident that she had the correct number she transferred the jewels to the grid game, placing one jewel per crown. This step acted as a form of scaffolding for the children. Then it was Shannon’s turn. She selected a card with two dots. Without hesitation she selected two jewels and placed them directly on two crowns thus eliminating the extra step that Anya had taken. Anya appeared to take note of this and on her next turn she copied Shannon’s had approach the game. “Sylva (1984) identified that play partners performed linguistic and metacognitive functions as well as having a social and emotional role as an audience, reflecting confidence back to the child” (Gifford, 2004, p. 107). Indeed, pairs are a supportive grouping for young children and may facilitate them from learning from each other rather than from a teacher. (Gifford, 2004, p. 107) This model is informed by Vygotsky’s “zone of proximal development” which describes the distance between where a child can problem solve independently and where they are assisted by an adult or a more experienced peer (Kirova & Bhargava, 2009, p. 4). This provides an example of a practitioner supported situation that was safe for children to take risks (Gifford, 2004, p. 100). In this incident I witnessed Jessica’s increased attention to, or noticing of, the small details of children’s mathematical thinking and development. Having been provided with information about stages in counting Jessica demonstrated that
she was able to accurately assess their understanding and learning during a playroom activity, and share this with me.

Further, there was evidence that the increased awareness of the developmental stages and the complexity involved in counting accurately led to educators reflecting on their practice, and as a result began to be more intentional in their selection of toys and equipment for the children. In conversation, Jessica described how when she was choosing new materials for the playroom she evaluated them first: “Yes, they could use this, but they are not ready for that yet”.

Jessica referred to her development and sense of confidence again in the interview:

*I am more aware of whether it is a true math circle or just something about math. I am more aware when I am putting toys out. I know what the stages are. I know about patterning and number sense.*

Moreover, there is evidence that educators not only began reflecting on their own practice, but they also began to notice and think about the practice of their colleagues. In an interview, Laura observed the following about her co-workers:

*I have heard the staff using math terms such as “Which one is bigger?”, “Which one is smaller?”, and I have been using them. I am seeing math a lot more. I have been listening more and I have heard more math talk among the children.*

Notably, this example provides further evidence of the embedded cycle of looking, thinking and acting. Laura not only recognizes her increased use of math language, but is noticing and reflecting on the practices of her peers. It appears that this increased awareness
of content and pedagogy (what to teach and how to teach) gained through the job embedded teacher development is positively influencing her teaching and ultimately improving children’s experiences of mathematics in her program.

One year after the project finished Jessica was been hired by a local school board to work as an Early Childhood Educator in a kindergarten classroom. Her eyes lit up when she recounted setting up the classroom with the teacher:

First of all I noticed the teacher is really focused on literacy and language....we have set up these math bins,...we have just put all kinds of coloured stones in them...that’s all and we will observe the children using them and we will ask them, “What is your rule? What is your rule?” No instructions...just see what they do and see if they can explain it. I put some things in a bin and the teacher said, “but that’s not math” and I said “yes, it is look they can sort, they will measure with these. It’s math”. The teacher said, “you’re right”. I had also brought in the binder you gave us to put things in and the teacher asked where I got it from. I told her about how you worked with us and modeled things and answered questions and showed us about the children doing math. She said, “I want this”. So she wants me to do the math and she’ll do the literacy. (Jessica, in conversation, September 2012)

Jessica described how she negotiated her role as an early Childhood Educator working with a teacher in a full day Kindergarten classroom. Her conversation provides powerful evidence of the effectiveness of the job-embedded teacher development provided through the research project. Jessica’s enthusiasm, positive disposition towards mathematics, and her confidence in providing and evaluating mathematical experiences for young children were clear.
Critical Incident # 3
Shay, 3 years, uses fractions to “share her blob”: coaching educators in the moment to notice math

There were occasions when I acted as a coach to mentor a teacher in noticing the mathematics in children's play. An example, of this type of mentoring occurred during the final observation in week 12 at a table top centre where there was a substance educators call “blob”. It is a sensory material similar to the commercial product Silly Putty. It can be cut with scissors or cookie cutters, but does not roll into balls well. It will also spread to cover the surface of the container it is in. An educator sat at the centre with one child playing with the blob. Another child approached and asked for some blob.

Shay was hesitant at first so the educator encouraged her to give the child a little bit. Rather than simply breaking off a piece of blob to give to the child, Shay without hesitation, went about cutting the mass of blob. First, she cut the large piece into two somewhat equal pieces. Then she proceeded to cut one of the pieces into two equal pieces, and so on, until she had created in, fractional terms, a piece of blob equivalent to one sixteenth or ‘a little bit’ as requested by the educator! She approached the task in a very systematic and logical manner. Indeed, if asked she would have been able to justify mathematically that this small piece was indeed a little bit of the larger mass. I wrote in my journal,

*As an educator/researcher I felt privileged to have been able to witness the child’s cognitive processes and sophisticated understanding of proportionality. (May 31, 2010)*

At the appropriate time I asked the educator if she noticed how Shay had approached the task. She admitted that, while she was aware that Shay had followed through on her
request and handed the other child a small piece of blob, she had not noticed anything else. The researcher demonstrated the process Shay had used to determine what a little bit of blob was.

The teacher present in this incident was not involved in the project, however, there is evidence that the presence of the researcher as a perceived expert and mentor led to teacher’s increased attention to children’s mathematics. Emma noted,

The children are more aware of math because the teachers are more aware of math. Things like counting. The one to one nature…touching each item as you count. I saw Shane wait until the teacher touched the object before he said the next counting word.

In her interview, when asked if the project had made a difference to how mathematics is experienced in the program, Katrina made the following evaluation:

Yes, it has been a focus for activities. It has brought math to the forefront. You have brought new activities into the room that have made staff think about math. They have observed them. You have talked about them and demonstrated them making it easier to see the math. There were things that we may not think of as but is in fact math.

These comments provide further examples of the research spiral of looking, thinking and acting on the part of the teachers and researcher. Of significance is that this approach was even adopted by the children, as can be seen in what I witnessed at the beginning of the last observation in the Junior Room:

On the day of the last observation in week 12, I entered the room and observed a child kneeling on the bench of a child sized picnic table that was part of a camp site set up in the
dramatic play area. Play food was scattered on top of the table. Anya held up a piece of play
pizza. She announced to her friend who was sitting across from her in the play tent, “It looks
like a triangle”. She then proceeded to touch each side and say, “One side, two sides, three
sides”. For many reasons this was a powerful and emotional moment for the children,
teachers and myself. This moment provided evidence of the presence of mathematical
thinking in the room. The level of confidence and comfort with which Anya provided the
mathematical proof as to why the pizza looked like a triangle was palpable. She
communicated this with her peer. She looked, thought and then acted.

**Senior Preschool Room**

**Context**

The Senior Preschool room is licensed for 18 children between the ages of 42 and 60
months. Typically, many of these children are enrolled in Junior or Senior Kindergarten, and
attend the child care program on the days they are not in school. The room is staffed by two
mature educators who have worked together for a number of years, and another staff working
with children with exceptionalities. She completed an Early Childhood Diploma
approximately 2 years ago and would be considered a new graduate. She has had little
experience in programming for preschool-aged children.

As expected, the observations in this room revealed both similarities, and some
fundamental differences between the two playrooms involved in the project. As children
mature they are better able to self-regulate, control impulses and successfully separate from
their parents while at day care. In the Senior Room there was notably less required teacher
assistance and intervention. The children’s increased independence with self-help skills, such
as toileting and dressing, their longer attention spans, well developed play skills and knowledge of routines were clearly apparent. The fact that children in the Senior Room were successfully advancing along the developmental continuum was evident in a number of areas.

**Math**

Children, often working in pairs, were frequently involved in one activity for the entire playroom observation. Nathan and Daniel, two of the older children, were observed, on a number of occasions, playing together at one activity for more than 45 minutes. These activities often included mathematics, for example, playing board games such as snakes and ladders, and tiling a large area of the carpet. In the second observation, siblings, Clara and Gavin, spent the entire observation stringing discs on to a string, and comparing the lengths of the strings by laying them side by side on the carpet, and then holding them up vertically.

**Critical Incident # 4**

**Eve’s house: how a simple question can tell us about children’s mathematical development**

Again, there were examples of children using materials in unconventional ways to explore mathematics. In week 6 Katrina wished to observe the children for the second time during the project while I took on her role as educator in the room. Not long into the observation Katrina drew my attention to Eve’s tiling on the carpet using wooden, two-dimensional shapes from a stacking and sorting toy. When I asked Eve to tell me about her work, Eve explained that she had made a house, and proceeded to describe each room, a path leading to the garden, and stairs leading to the basement. Much to my amusement she even explained that daddy was not in the kitchen a lot, unlike mummy. He always read the paper
in the living room, and this did not please mummy. This provides an example of where appropriate questioning of children’s work and play (Sullivan & Lilburn, 1997) provides great insight into their perceptions of their world. This example demonstrates that Eve has flexibility in thinking and can use one material to represent something else. In her interpretation of a map or blue print of a house, she used scale and proportion, and accurately identified components of the house in relationship to each other, for example, a path that led to the house, stairs that went down into the basement, and a living room next to the kitchen.

*Figure 2. Eve’s house.*

Another difference between the Junior Preschool Room and the Senior Preschool Room, that should be noted, was teacher experience. The two program staff, Carol and Katrina, are seasoned educators having worked in the program for many years. The enhanced staff has worked in the program for just over 2 years. It was immediately apparent that
Katrina had a positive and intentional approach to mathematics. Just over a year ago she had attended two workshops I had facilitated, and on the first day of the project she shared with me, feedback related to her integration of math into her programming using ideas from the workshops.

Further, Katrina drew my attention to a bulletin board on which were samples of pictures children had created using 10 small, black squares. This was an activity presented at my presentation based on Donald Crew’s book, *Ten Black Dots* (1968). Katrina had also documented discussion that had taken place among the children regrading the pictures. For example, Carl described his picture as a rainbow, however, Jason commented that it looked like the mouth of a tunnel. This showed evidence of conversations about mathematics, or mathematical discourse, in the playroom.

Katrina was one of two participants who embraced the opportunity to observe the children while I assumed her role as playroom teacher (weeks 4 and 6). Katrina demonstrated her ability to notice children's explorations of mathematics while playing, and on more than one occasion, drew my attention to such activity.

It became clear from the beginning that Katrina maintains a balance between child directed and teacher directed programming. She notices when children engage in mathematics in their play, and also is very intentional in providing teacher directed mathematical experiences for them. She also had previous exposure to teacher development in mathematics.

In an interview, Katrina summarized her approach to teaching and her experience of the project as follows:
I enjoyed the conversations about math, the information, the perspective, ideas, activities. I liked writing in the journal...there’s a lot there. I think there needs to be a balance between actually teaching and the free flowing part of the playroom. I need to learn. It is part of who I am.

It could be said that, in a number of ways, Katrina represents an ideal candidate for job embedded teacher training, as modeled in this project. She has experience, background knowledge, a positive disposition towards mathematics and learning in general. Further, there are many examples of her ability to notice children’s mathematics, reflect on it and plan ways to extend their understanding.

The second main educator in the room, Carol, described her love of cooking with the children as an entry point to mathematics in her programming. In fact, Carol has provided teacher development on this topic. However, Carol admitted that her involvement in the research project had increased her awareness of the different strands of mathematics that are involved in cooking for example, measurement, counting, time, temperature, and fractions. Carol describes it as follows:

I am more aware and I am rethinking things and extending them. I enjoy baking with the children, but I am aware of how to extend this activity.

She goes on to describe her involvement with the project:

It has made me more aware of the environment. It has made me aware of the continuum and try to include math. It has been a refocus.

Based on the initial observations, and in discussion with the staff, it was decided to make three-dimensional geometry the primary focus for the modeling of teacher directed
activities. The children were clearly interested in this, and staff felt they would like to learn more about geometry, and the mathematically correct terms for talking about geometry. A secondary focus would be working with a hundreds chart. This second focus was based on observations that children were interested in “big” numbers, enjoyed playing chutes and ladders using numbers 1 to 100, and filled 10-by-10 pegboards with pegs.

**Critical Incident # 5**

**Morgan makes a box: mathematical knowledge empowers children....**

I had planned and implemented a circle using nets to create cubes in week 10 of the project. The children explored models of three-dimensional solids, including cubes and cones. Then they compared them to real objects, for example, a dice, an ice cream cone, a clown’s hat. Then, they took apart a candy box to see how it was made from a specially shaped, flat or two dimensional, piece of cardboard. When correctly folded it became a three-dimensional container with volume and capacity. Then the researcher gave each child a copy of a net for a cube. The children counted and decorated the faces of the cube. The teachers assisted the children with cutting and gluing to form the cubes. Daniel, who plays a lot of board games, at home and at day care, opted to make a dice. Unassisted, he proceeded to mark in the correct pattern of dots, one to six, with a different number on each face. It was very clear that he was very proud and excited at what he had created.

Carol noted in an interview,

*I sent Daniel home with two nets and he made a dice and so did his brother.*

*He came in the next day and reported, “They are the best pair of dice ever!*
This also provides an example of engaging parents in their children’s learning, and how teachers and parents can make connections between the mathematics at home and at day care.

The following week (week 11) I arrived for the playroom observation. Carol approached her and told her that she had a story to share. It was apparent that Carol was very emotional, and on the verge of tears. She had described the incident in her journal:

*It was at the art table....four girls were coloring an talking in the afternoon. One of the girls mentioned that it was her dad’s birthday. The rest decided to make him pictures. I noticed that one of the girls was making something else. She selected a number of pieces of paper and announced that she was making “something to put them in”. The others left to have snack. She continued to add glue and tired to keep the pieces to stay together. At this point she ask for help. I helped her hold the pieces where she asked me to. We waited until the glue had tried a bit and I gave her some tape to hold tow of the pieces. She had made a box for the birthday pictures to go in!*
Carol refers to this incident again in the interview when asked which aspect of the project she found most beneficial:

*The modeling. For example, the box. It was so concrete. It built on what they already knew. Then a child made one independently and was successful. She was sharing and become softer than in the past.*

This is a story of deep and powerful learning on the part of the child, the teacher, and the researcher. This is an example of how mathematical knowledge can empower children...Morgan needed a container to hold cards, and she knew how to make one, because she had learned this in a circle prepared by a teacher. It could be said that Morgan in a similar way to the researcher and teachers was also following the cycle of observing, reflecting and acting as she embraced her challenge.
It appears that the teachers observed this incident, reflected, and acted on it, and in doing so changed their practice. Carol referred to providing children with other mathematical tools:

*Paighton wanted a template of a triangle so she could show other children how to make a star from triangles. That’s where those triangle work sheets came from.*

Here is evidence of job embedded teacher development influencing children’s experience of mathematics.

The third and final participant in the Senior room was Jasmine who provides an interesting contrast to the other more experienced teachers. While all teachers were enthusiastic about the project for Jasmine there was an element of redefining her identity as a teacher. Jasmine embraced, with genuine excitement, an emerging and positive disposition towards mathematics. She admitted that she had “always struggled with math especially in high school and [her] focus was not on math until the project”.

From her journal and the interview there is evidence that the job embedded teacher development model was particularly effective for Jasmine. As a fairly new teacher, with a history of disliking mathematics, Jasmine responded well to the coaching-in-the-moment and modeling of activities. In an interview, Jasmine described how she had benefited from coaching from an expert,

*That day when you were here and I was with the children and the board with the screwnails and I suddenly realized that that could be a teachable moment in math. I find I am able to expand things to do with math and able to talk to the children about math.*
Jasmine was beginning to realize the importance of mathematics and to notice it everywhere.

*It is incredible how much math I see amongst the children every single day, that I don’t realize unless I am looking for it.*

Further, she was also reflecting on children’s developmental stages.

*I have noticed on occasion that the younger children become very excited at the prospect of math i.e. counting, sorting, seriation etc. I have noticed with some of the older children it does not interest them to the same degree. They will choose activities that have to do with math, but when asked about it, they don’t show the same degree of genuine excitement.*

When asked to describe her perception of the benefits of the project Jasmine’s excitement permeated the interview.

*The experiences in the playroom are expanded and the children get more out of their play. I remember one day Kate was counting...sorting and comparing how many blue there were she was so excited about it and then I was excited because she was.*

In fact, when asked her opinion of a possible extension of the project she echoed all the components of the project.

*I think we would all benefit from it if it continued. I think more circles, creatives...having you observe, be that extra support...show us when the children are doing math. Show us how to ask open ended questions...not just giving the children the answer.*

Jasmine’s response is further evidence of her new awareness, and her ability to reflect on her practice in the look, think and act cycle. It appears that this development resulted in an
increase in Jasmine’s confidence in speaking to parents about their children’s development in mathematics:

*I think parents are really good with literacy but I don’t think they are focusing on the math. Literacy is huge...math is just swept under the rug. I was speaking to Ivy’s mum the other day...she was asking how she is doing. I talked to her about things I had noticed...I told her about Ivy’s ability to count, letter recognition. I told her to make it part of everyday life.* (Jasmine, interview)

One final example of the effectiveness of the professional development model comes from my research journal,

*Today, midway through the project, I was inundated with reports of observations of children engaged in math, not only from the participants in the project, but the site supervisor and one of the infant teachers. There was great excitement and enthusiasm in each of their faces. Each of them could not wait to share their story with me. They were hungry for this. Something big is going on here and I couldn't have wished for anything else from this project.* (May 11, 2010)

**Analysis of Participant Journals**

Five of the 7 participants submitted their journal to the researcher at the end of the project. Notably, the journals provided further evidence of the teachers’ increased awareness of children’s mathematics. The five journals contained between them 72 entries. Eleven themes emerged through the analysis and coding of the entries. Attention was paid to which strand of math the entry related. There were several examples of entries that were concerned
with more than one strand of math, for example, making a pattern with geometry shapes. The themes are identified in Table 2.

**Table 2**

*Type of Journal Entry*

<table>
<thead>
<tr>
<th>Type of entry</th>
<th>#</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number sense</td>
<td>40</td>
</tr>
<tr>
<td>Patterning</td>
<td>3</td>
</tr>
<tr>
<td>Measurement</td>
<td>4</td>
</tr>
<tr>
<td>Data management</td>
<td>6</td>
</tr>
<tr>
<td>Geometry</td>
<td>6</td>
</tr>
<tr>
<td>Geometry and number sense</td>
<td>6</td>
</tr>
<tr>
<td>Geometry and patterning</td>
<td>2</td>
</tr>
<tr>
<td>Awareness of math in general</td>
<td>1</td>
</tr>
<tr>
<td>Awareness of children’s development</td>
<td>2</td>
</tr>
<tr>
<td>Comments about the project</td>
<td>1</td>
</tr>
<tr>
<td>General comment</td>
<td>1</td>
</tr>
<tr>
<td>Total # of entries</td>
<td>72</td>
</tr>
</tbody>
</table>

The fact that five teachers wrote a total of 72 entries about their observations of children’s mathematics is strong evidence of their growing awareness of children’s math. It could be said that all but two comments are directly related to teachers noticing math, and provide further evidence of the positive influence of the job-embedded professional
development. The journals verified that the participants were indeed noticing and interpreting children’s mathematical explorations. Further, participants noticed math, not just in play, but during routines and mealtimes.

The results showed that over 50% of the entries by participants referred to accounts and reflections related to number sense, particularly counting and estimation. The next most frequently occurring entries were concerned with the mathematic strands of data management (6), geometry (6) and entries that involved both counting and geometry (6). The fact that over half of the entries were concerned with counting is consistent with research that suggests that educators and families primarily think of math primarily as counting (Ginsburg et al., 2008, p. 4). Unquestionably this is a place to start. Indeed, it is not intended that equal time be spent on each strand of math. Young children do pay attention to counting as they master this complex skill. Once mastered, attention shifts to other areas of mathematics. The next steps in teacher development involve broadening teachers’ definition of mathematics for young children, particularly in geometry and spatial reasoning. Research suggests that well planned professional development has been successful in focusing educators’ attention to children’s explorations in other areas of math and supporting their development (Copley, 2004; Hill, 2004; Samara & Clements, 2009). Interestingly, in this project, the participant who wrote about a several strands of mathematics in her journal entries was the participant most involved in professional development in mathematics prior to the project.
Insights from Surveys

As described in the methodology section prior to the beginning of the project all seven participants completed a pre-survey (see Appendix E) concerning mathematical disposition and confidence levels in supporting children’s mathematics. The surveys were analyzed and used to guide the project. Participants did not have access to the surveys again. At the end of the project the participants completed and submitted an identical post-survey. Five of the seven participants submitted this survey.

The surveys provided interesting data. First, only one participant listed math as a favorite subject at school, while subjects such as language arts and drama were more commonly listed as favorites. In both the pre-survey and the post-survey participant responses tended to cluster in the low to mid range for level of confidence for each of the 15 questions. All 5 participants reported confidence levels for each question in the post-survey to be the same or slightly lower compared to the pre-survey. Given the data collected from the journals and interviews the survey results surprised me and appeared to directly contradict other findings in the project. Indeed, I fully expected the participants confidence levels to have risen by the end of the project. However, it is possible to interpret the results from the post-survey as evidence of the participants emerging and authentic awareness of the depth and breadth of children’s mathematics. In other words, mathematics is much more than counting and even counting is more complex than participants realized. To this end, teachers were truly thinking about, and reflecting on the mathematics of which they had recently begun to notice and interpret through their involvement in the project. Moreover, it is possible that teachers confidence levels rise and fall as they try new teaching approaches, and their identity as a teacher of mathematics shifts. Notably, all participants enthusiastically
responded that they wished the project to continue, and may have, subconsciously reported lower confidence levels indicating their need for continued professional supports. In the end, in keeping with the research model, I decided to contact the participants to ask them how they would explain the decrease in confidence levels. I heard back from four of the seven participants, and interestingly each educator had a different explanation.

In conversation Mary responded,

*Yes, I think that is because after you came in and showed us things and we thought about how to put math in the program we thought “how could we have not realized that that was math!”. There is math in this and this, but we didn’t think of it.*

Certainly, Mary’s assessment reflected my explanation of the results. Carol identified the possible rise and fall of confidence levels. She acknowledged that when a teacher tries a new activity that does not go as they expected they tend to focus on “what went wrong”. While it is positive that the teacher is trying new approaches, a perceived failure would likely lead to a drop in confidence.

*You’d then have to get back up to where you were before, but over time confidence would go up to a new level.*

In conversation, Carol indicated the levels of confidence of which she spoke by raising and lowering her arm to illustrate visually the rising and falling confidence levels that a teacher may experience. I told her this reminded me of an expression a former professor of mine shared with our class. It went something like this, “There is no comfort in your learning zone and no learning in your comfort zone”. Carol affirmed that this echoed her thoughts.
The final two respondents represented two extreme views. Jasmine, a fairly new graduate, who currently works in a position where there is no requirement to plan preschool curriculum, expressed a general lack of confidence when it came to children's mathematics. She acknowledged the complexity of their development and felt that she “might do more harm than good”. Katrina provides a valid reason for ongoing and sustained professional development (Samara & Clements, 2009) which has the potential harness Jasmine’s initial enthusiasm as witnessed in the project, but provide encouragement and support in her attempts to actually implement activities.

In contrast, while the survey responses showed that there was no increase in confidence, Katrina, a seasoned educator felt that her confidence had increased.

*I would say my confidence level going in wasn’t too bad since bringing in math had been on my radar for a while.*

She attributed the perceived increase to the following two components of the project:

*More exposure to different ideas and ways to bring math into the daily program and by focusing more on it, including recording in the journal and talking about it with others, it became easier to have it present in my thoughts so it was easier to bring it into the activities.*

The varied responses provide a pertinent example of the complexities of teacher identity and the challenges of providing teacher development in mathematics. Each participant reported a different experience of the project, an example of the reason why a ‘one size fits all’ approach to teacher development is not the most effective (Copley, 2004; Hill et al., 2005; Samara & Clements, 2009).
Chapter Five
Conclusion and Discussion

The participants involved in the research project represented typical early childhood educators, with a minimum of community college diplomas, and at least 2 years of experience working in a child care setting. There is much evidence to suggest that the job-embedded professional development modeled in this project positively influenced the way children enrolled in program experienced mathematics. First and foremost teachers began to notice the math that children do in their everyday play. In addition to conversations, during 10 weeks of the project 5 of the participants wrote a total of 72 journal entries about observations they had made regarding children doing mathematics. This awareness of mathematics led to math becoming more visible to the children through conversations and material selection. Teachers identified that their attention to mathematics had increased, and this was, in turn, verified by their peers. Notably, teachers began to provide children with materials related to their interest in mathematics, for example, Carol sent children home with resources based on their expressed interests, and described the children’s responses as being extremely positive.

Furthermore, there is evidence that as the teachers’ awareness of the developmental stages of children’s development in mathematics increased the more intentional they were regarding the selection of materials and activities. For example, teachers began to understand that just because the children in the Junior Room could say the number words from one to ten, it did not mean that they fully understood what numbers actually meant. This awareness on the part of the teachers positively effected the children's experiences of mathematics in a
number of ways. There was an increased sensitivity to children's learning with improved support and scaffolding, for example, making sure children fully understood number concepts and cardinality related to numbers up to three before introducing further expectations. This in turn, helps children to feel secure and safe to explore. The selected materials were more likely to interest the children since they were in their—Vygotsky’s—zone of proximal development and less likely to frustrate them. This results in a more positive disposition towards mathematics.

It appears that as children sensed teachers’ support in their exploration they became more confident in expressing their ideas. Examples include Anya’s confident description and proof that the slice of pizza resembled a slice of pizza and Morgan’s creation of a box to contain cards.

**What Made This Professional Development Effective?**

Firstly, there is research to support the effectiveness of professional development that obtains and analysis with data collected from the setting in which the participants work. “Professional development approaches linking to effective pedagogy and children's learning in early childhood settings involved participants in collection and analysis of data from their own setting” (Mitchell & Cubey, 2003, p. 18). This was meaningful, powerful and engaging since it involved the children participants guided and interacted with on a daily basis rather than examples from other sources of research. Through the data collected participants got to better understand individual children’s interests and developmental stages which in turn positively influenced the children's experiences. Indeed, this is an example of the synergy of research and practice (Bobis et al., 2005, p. 31) whereby teachers become researchers.
Secondly, a unique factor of the professional development was that it extended over a number of weeks. This allowed the teachers time to consolidate, reflect on, and practice new learning in between visits by the researcher. Schoenfeld (2011) reminds us that sustained professional development can cause a shift in teacher confidence and feelings toward math (p. 236). Katrina referred to this feature:

I believe that the sustained element was very important. It is embedded and occurring on a regular basis. It (mathematics) is always happening and we need to build on it and make it part of the curriculum.

Thirdly, the design of the project was informed by research on successful teacher development models. Samara and Clements (2009) identify that “Observing actual practice and follow up assistance was ranked highest when participants were asked what strategies they felt would have the largest impact on their work with children” (p. 351). In emulating their findings, I was present as the teachers worked with the children. Samara and Clements (2009) purport that “professional development must illuminate children’s interests and capabilities in mathematics. Teachers must realize that children's mathematics is wider and deeper than they usually realize” (p. 351). To this end, I drew the teachers’ attention to children’s explorations of mathematics, either coaching in the moment (Rudd, Lambert, Satterwhite, & Smith, 2009, pp. 63–69) or sharing and discussing photographs of children’s work. Developmental stages were identified, followed by the planning and modeling of teacher lead activities, that supported and extended children’s understanding. All participants reported that aspect significantly increased their awareness of children’s mathematics and developmental stages. Teachers noticed more mathematics, interpreted it, and gained confidence in enriching children’s experiences, through the selection of materials and
activities. It is likely that further involvement in professional development would lead to increased awareness of all strands of math (Ginsburg et al., 2008, p. 4).

Finally, in many ways, the teacher development was personalized and built on each teacher’s existing knowledge and experience (Copley, 2004; Hill et al., 2005; Samara & Clements, 2009). Teachers were given opportunity to observe the children, ask questions, request resources etc. This approach was effective for all participants from new graduates to highly experienced teachers.

Significantly the act of teacher noticing in elementary school mathematics is an emerging field of research (Sherin et al., 2011). Findings from this project contribute to our collective understanding of teacher noticing at the early childhood level which will lead to improved experiences of mathematics for children. Schoenfeld (2011) concludes that it is possible to develop noticing through teacher development in this area (p. 235).

While it is unlikely that funds would be available to implement such intensive job embedded teacher development, there are still many components of the project that can be implemented in early learning/care environments. Findings from this project could be used to inform staffing decisions, for example, the intentional pairing of a new graduate with a more experienced teacher, where the later teacher acts as a mentor for the former. Equally, pairing teachers with demonstrated confidence in supporting children’s mathematics with teachers with lower levels of confidence has the potential to enhance children’s experiences of mathematics. Furthermore, this provides a mentor for the new teacher and a fresh focus for a teacher at a different stage in their career who is seeking out leadership opportunities (Katz, 1972).
What Are the Next Steps and What Further Research Can Be Considered?

Increasingly the focus in early education is on play-based learning yet there is evidence that teachers continue to struggle with what this looks like particularly in mathematics. The examples of children's mathematical development and understanding explored in this thesis all occurred during free play and serve to provide rich examples of observation, thinking and acting that can serve as examples in future teacher development.

Furthermore, clearly more attention needs to be given on children’s early mathematical development in teacher training. The participants in this project had taken required child development and curriculum courses, but reported little attention was given to mathematics. As a part-time faculty member in an early childhood education program at a community college, I can verify that students received very little in the way of pedagogy related to mathematics.

Further, in order to measure the effectiveness of professional development there must be a system in place to evaluate and to track participants to determine if the professional development offered actually resulted in positive change for the children.

Finally, sometime after the end of the project I dropped in to the centre to visit. I happened to be the staff room when Brenda, a toddler teacher, shared with me an unsolicited example of the scope of the project’s influence. While Brenda had been very interested in the displays of photographs and materials I had set up in the foyer, she had not actually been a participant in the project. In fact, as a teacher in the Toddler Room she worked at the opposite end of the building from where the research took place. She sat in the staff room, looked over to me and said,
I don't know how to describe it, but you changed the way I see things. I was at my nephew’s house the other day. He was playing on a carpet that had a number of squares as part of the design. I watched him closely and realized he was doing something different with his toys in each square. He covered one square completely with blocks. In another square he lined his cars around the edge. In another he made a pattern with blocks, one red, one blue, one red, one blue. I remember thinking...he’s doing math there, there, and there. Before your project I never would have noticed that. (Brenda, in conversation)
References


Clarke, D., & Clarke, B. A. (2005). Effective professional development for teachers of mathematics: Key principals from research and a program embodying these principals. In D. L. Ball & R. Even (Eds.), *15th ICMI Study Conference: The Professional Education and Development of Teachers of Mathematics* (pp. 1–6). Sao Paulo, Brazil: The International Commission on Mathematical Instruction (ICMI), Aguas de Lindoia.


Appendix A
Research Ethics Board Approval Letter

PROTOCOL REFERENCE # 28145

December 26, 2012

Dr. Linda Cameron
Curriculum, Teaching and Learning
OIIE/University of Toronto
252 Bloor St. West
Toronto, ON M5S 1V6

Ms. Susan J. Scoffin
Curriculum, Teaching and Learning
OIIE/University of Toronto
252 Bloor St. West
Toronto, ON M5S 1V6

Dear Dr. Cameron and Ms. Scoffin:

Re: Your research protocol entitled “Exploring how preschool children experience mathematics in one early learning and care environment”

The Social Sciences, Humanities & Education Research Ethics Board has reviewed this protocol under the REB’s delegated review process. Review comments are enclosed for your information and response.

Please address review comments point by point in a cover letter and attach the revised protocol and/or supporting documents to your response. Additions/revisions to the original protocol and supporting documents should be bolded. If possible, please limit attachments to two documents. The revised protocol does not need to be signed by the Departmental Chair/Dean.

Please submit your revisions by email to ethics.review@utoronto.ca within 60 days of this letter. Make sure to include protocol reference number and PI name in the subject line (e.g., Revisions to #12345, Jane Doe). Alternatively, you can fax the revisions to 416 946-5763.

Yours sincerely,

Dean Sharpe, Ph.D.
Research Ethics Board Manager—Social Sciences and Humanities
Review Comments:

Rationale (11)
Could the researcher please clarify how aspects of the study concerning children’s learning and abilities can be determined through observation and speaking only to teachers? The concern here is that the rationale seems to suggest that the children are being observed (e.g. “...listening to conversations between children and between teachers and children...”) to some extent, yet the letter to parents suggests only the teachers are being observed.

Methods (12)
Audio and video recordings are mentioned in the protocol but are not discussed in the appendices describing to the research participants how the research will be conducted. Could the researcher please comment on how anonymity can be promised if there is videotaping of sessions, as well as how children will be excluded from videotaping if the parents are promised non-identifiability of their children?

Consent Process (19); Consent (Document) Issues
In the information and consent forms, the researcher should include contact information for the supervisor.

Please include information on the use and storage of audio and video recording(s) in the consent or information forms if these methods will be used. If the choice is made NOT to record, please indicate this change in the revised protocol.

Please review the signoff portion of the consent form for minor typos and spelling errors.

Consent by an Authorized Party (20)
The researcher indicates that the board of directors of Trent Child Care Inc. will have been approached for consent and that a letter supporting the research will be sent if they consent. Please include that letter as an attachment to the revised protocol or provide an explanation of how consent will be sought if not granted already.

Missing Documents and Other Issues
Letter of consent from Trent Child Care Inc. is missing from the protocol.
Appendix B
Letter of Approval to Conduct Research

Monday, February 28th, 2001

Dear Members of the Ethics Review Committee,
Please be advised that Susan Scoffin has approached Trent Child Care Inc.’s Board of Directors to get permission to conduct her research project *Understanding How Young Children Experience Mathematics in One Early Learning and Care Environment* at its Campus site. After taking the time to examine the documentation provided by Ms. Scoffin, her request was granted by the Board of Directors. We are pleased to welcome and support Ms. Scoffin and wish her every success with her research. We congratulate her on her academic endeavours.

Beckie Evans
Board President

Marie-Anne Saucier
Executive Director
Appendix C
Information Letter to Parents

Dear Parent/guardian, March 22 2011

My name is Susan Scoffin and I am a registered and experienced Early Childhood Educator as well as a qualified Primary/Junior teacher. I am currently enrolled as a graduate student at the Ontario Institute for Studies in Education at the University of Toronto (OISE/UT). I have completed the required coursework for a Master of Arts degree and am excited to begin the research component of my thesis. I have received ethical approval from the University of Toronto for my research project(Protocol Reference # 26145). The Executive Director, Marie-Anne Saucier and the Board of Directors of Trent Child Care Inc. have given me permission to conduct the research in the preschool rooms of the Campus site. This letter is intended to inform you, as a parent/guardian, of the project.

In North America, in recent years, a great deal of attention has been paid to early literacy while there has been significantly less interest in early numeracy. To gain further understanding in this area I have made early numeracy the topic of my research. I am interested in exploring how children experience mathematics in early childhood environments. I will be conducting a total of twelve playroom observations commencing in early April. These observations will take place during free-play time and occasionally at circle time. I am interested in incidents involving mathematics and will be looking at such variables, for example, as the frequency of incidents, the duration of incidents, the role of the teacher in these incidents. These mathematical incidents may include skills such as counting, sorting, comparing, making predictions, and understanding spatial/geometry concepts. This research is not about assessing children’s skills and individual children will not be identified in the research.

My role as a researcher will be to build on existing knowledge and understanding of children’s experiences with mathematics and offer support and resources to staff and parents/guardians in this matter. My work is informed by current research and guided by the Ontario government’s document Early Learning for Every Child Today (ELECT). I will present my findings at the Annual General Meeting of Trent Child Care Inc. in September of this year.

Should you require further information do not hesitate to contact me at susanscoffin@trentu.ca or 705-745-4081.

My academic supervisor is Dr. Linda Cameron and she can be reached at l.cameron@utoronto.ca or (416) 978-0321.

Sincerely,

Susan Scoffin, R.E.C.E., BA (hons) BEd.
Appendix D
Consent to Participate

Dear staff member,

My name is Susan Scoffin and I am seeking four preschool teachers to be involved in a research project for an MA thesis on children’s experiences of mathematics in early learning environments. Participation is strictly voluntary and individuals who agree to participate may withdraw from the project at any time, and may decline to answer any question or participate in any parts of the procedures/tasks – all without negative consequences. The study will run for twelve consecutive weeks from the beginning of April 2011 and until the end of June 2011. The research will involve weekly observations of the playrooms that will be carried out when convenient for the teacher. All individuals involved in the project will remain anonymous. In all written work pseudonyms will be assigned to children and teachers. All information will be kept locked at the Trent Child Care administration office and will be destroyed upon completion of the project.

Results of the study will be presented in the form of a report to the Trent Child Care Board of Directors, site supervisor, and staff of the program. It is possible that results may be published or presented at conferences. Again pseudonyms will be used to maintain confidentiality. The fact that the research site operates as a typical preschool program in the region will increase the degree of anonymity of participants.

Teachers who volunteer to be involved will be asked to complete a confidential survey about their experiences of math in early learning environments at the beginning and at the end of the project. This will help to assess the overall effectiveness of the project. The researcher will facilitate ongoing discussions based on observations and provide opportunities for teachers to observe the children. Teachers may be asked to participate in brief meetings as required. These will be set at convenient times. At any time, and with little or notice, a participant may withdraw from the project or refuse to answer a question or to participate in a particular activity. There will be no consequence for doing this.

All staff time involved in this project may be counted towards professional development hours in the community-based Raising the Bar program.

Through this research project I hope to provide resources and materials that will further support the excellent programming quality that Trent Child Care is known for.

Thank you for your consideration,

Yours sincerely,

Susan Scoffin, R.E.C.E., BA, BEd.
Signed Consent

I __________________________ have read or had read to me and understand the terms of this project and agree to participate in the research project described under the conditions outlined in this letter. I understand that at any time I may refuse to participate in an activity or refuse to answer a question or withdraw from the project at any time all without negative consequences.

I understand that if I have any concerns or questions about my rights as a participant I can contact the Office of Research Ethics at ethics.review@utoronto.ca or 416-946-3273.

Dr. Linda Cameron is my faculty advisor and she can be reached at phone: (416) 978-0321 email: lcameron@oise.utoronto.ca

Signed this day _____________________ in _______________________

____________________________________
Signature.

Contact information

Susan Scoffin (R.E.C.E, B.A., B.Ed.)
745-4081
susanscoffin@trentu.ca

Please take a few moments to complete this short survey. It should take about fifteen minutes. Be as honest as you can. You do not have to put your name on the survey. Your answers will help me design the project in a way that will best meet your needs.

Section A Please mark with an ‘X’ the response that best describes you.

1. I enjoyed math in elementary school.
   very untrue  o  o  o  o  o  o  very true

2. I enjoyed math in high school.
   very untrue  o  o  o  o  o  o  very true

   very untrue  o  o  o  o  o  o  very true
4. Circle your favorite subjects at school:

- Art
- Drama
- Math
- English
- French/languages
- Geography
- History
- Mathematics
- Science
- Physical Education

5. I wanted to work with pre-schoolers so I wouldn’t have to do math.

   very untrue o o o o o very true

6. Math does not belong in preschool.

   very untrue o o o o o very true


   very untrue o o o o o very true

8. There are many teacher resources about math for preschoolers.

   very untrue o o o o o very true
Section B Confidence levels

In this section please write an X on the --------- to indicate where you would rate your confidence level in the following areas.

Example:

**Very Confident-------------------------------X-------------------------------Not at all confident**

9. I understand how young children’s mathematical abilities develop.

**Very Confident _ _ _ _ _ _ _ _ _ _ _ _ _ Not at all confident**

10. I am able to identify when children are doing math in their everyday play.

**Very Confident _ _ _ _ _ _ _ _ _ _ _ _ _ Not at all confident**

11. I am able to identify and highlight the math in everyday activities such as cooking or art.

**Very Confident _ _ _ _ _ _ _ _ _ _ _ _ _ Not at all confident**

12. I am able to identify and talk about the mathematics in the world around me.

**Very Confident _ _ _ _ _ _ _ _ _ _ _ _ _ Not at all confident**

13. I am able to identify and highlight mathematics in children’s books.

**Very Confident _ _ _ _ _ _ _ _ _ _ _ _ _ Not at all confident**

14. I am able to help children build on the math they do in their every day play.

**Very Confident _ _ _ _ _ _ _ _ _ _ _ _ _ Not at all confident**

15. I am able to extend children’s mathematical thinking.

**Very Confident _ _ _ _ _ _ _ _ _ _ _ _ _ Not at all confident**
16. I am able to plan a circle that about a mathematical concept
   Very Confident _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ Not at all confident

17. I am able to plan an art activity that includes a mathematical concept.
   Very Confident _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ Not at all confident

18. I know where to find resources to help me provide math related activities in my program.
   Very Confident _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ Not at all confident

19. I know where to find resources to help me provide literacy activities in my program.
   Very Confident _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ Not at all confident

20. I am able to make math an interesting and exciting part of my program.
   Very Confident _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ Not at all confident

21. I can identify the level a child is at in their mathematical development.
   Very Confident _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ Not at all confident

22. I am able to speak to parents about children’s development in mathematics.
   Very Confident _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ Not at all confident

23. I can identify the level a child is at in their language/reading development.
   Very Confident _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ Not at all confident
Please provide any additional comments:

___________________________________________________________________

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Thank you for taking the time to complete this survey,

Susan Scoffin
(705) 745-4081 susanscoffin@trentu.ca
Appendix F
Interview Questions

*Project specific*

- Has this project influenced how children experience math in this program? If so how?

- Which aspect has had the most influence?

3. Has this program influenced how you think about math in an ECE setting and if so how? Parents?

4. What aspect of the project was the most significant for you? Why?

*General context in which project took place.*

5. What do you most enjoy about your work?

6. What do aspects of your work do you find easy?

7. What things about your work do you find challenging?

8. In your field of work what do you wish you knew more about?

9. In your field of work what would you change if you could?
Appendix G

Background Information:

This appendix provides further information about children’s early mathematical development that served to inform the research project. It contains a very small percentage of what we know about children’s early development in mathematics, however, it does include information that related to this project and that was shared with staff as resources.

The information is organized in the five strands of mathematics which are number sense, patterning/algebra, measurement, data management/probability and spatial sense/geometry. The level of cognitive development relevant to this section is between 30 and 60 months.

Number sense

Humans are born with a fundamental sense of quantity (Geary, 1999, as cited in Samara & Clements, 2009, p. 16). The foundational mathematical knowledge begins during infancy and undergoes extensive development over the first five years of life (Samara & Clements, 2009, p. 16). Children as young as two and three compare collections in everyday situations (Clements & Samara, 2009, p. 43).

Ordinal numbers describe the position in a series. Most children learn first, second and last early, but the other numbers later. (Clements & Samara, 2009, p. 45)

The ability to recognize or name a number without counting is called subitizing, (Samara & Clements, 2009, p. 29) and this ability appears to precede and support the development of the ability to count (Samara & Clements, 2009, p. 50).

Young children often associate numbers with people e.g. when they are three, they may see ‘threeness’ as part of who they are, and perhaps associate ‘thirty five’ with their mother. I have witnessed this when counting children in a line up. I have pointed to the third child and said the word “3”. They have responded quite indignantly that they are in fact “4” and remind of when they had their birthday!

How many are there? Children may not be able to answer this question even after counting the objects and often see this as a request to count. They will begin counting again.

Cardinality refers to the understanding that the last number word said is how many are in the set (Clements & Samara, 2009, p. 21). This understanding defines the difference between reciting number words and the ability to count.
“Counting is the first step by step procedure that children learn that solves certain problems—determining how many elements are in a finite set” (Clements and Samara, 2009, p. 22).

**Counting is complex includes 5 principles.**

- Children need to know the stable order by assigning the number words in the same order.

- The one to one principle is where one number word is assigned to one object. Note that children sometimes count two objects for seven (seven) because it is the only two syllabled number word between 1 and 10 (Clements & Samara, 2009, p. 24).

- The cardinal principle which means that the last number word said is how many are in the set.

- The order irrelevance principle means that it does not matter in which order the objects are counted.

- The abstraction principle means that all the principles apply to any collection of objects (Samara and Clements, 2009, p. 57) In addition the collection of objects can be moved to another place and still contain the same number of objects.

From here children can count things that they cannot see or hear (Samara & Clements, 2009, p. 64).

Typically children learn their first counting word by 24 months. The word is usually two. Children have a desire to count and a curiosity about the number system and attempt to count at a young age (Baroody, 2004; Fuson, 1998; Griffin, 2004; Steffe, 2004 in Samara & Clements, 2009, p. 53).

By age 5 most children can count up to 20 to 30 objects (Samara & Clements, 2009, p. 59).

A more complex task that develops later is the ability to count out a group from a larger collection. Until children master this they will just keep counting.

In the preschool years there is an emerging understanding of zero (Clements & Samara, 2009, p. 22).

Very young children use their spatial sense to understand quantity, for example, this pile is bigger so it is more; these two cookies take up more space than one cookie so therefore is more than one. On a five and ten frames children will focus on the total space that is covered rather than looking at the number of units that are covered.
This is also related to conservation of number:

* * * * *
* * * * *

Children will believe that there are more * in the second line because they take up more space (Piaget, 1967, as cited in Clements & Samara, 2009, p. 19).

Next children compare groups, for example, if I have a group of three bears and a group of three bowls there is one bowl for each bear. The groups are the same size.

This comparison of groups develops into one to one correspondence where the focus is on the units in the set rather than the space the set occupies.

Counting is like addition because each time we say a number we are adding another item...6 (plus one) 7 (plus1) 8 (plus 1) 9 (plus 1) 10.

Younger children practicing counting beyond 10. They say number words, but not in the correct order, but interestingly they say number words between 11 and 20 they do not go back to the number words between 1 and 10.

*What children need*

Children learn to count through repeated experience (Fuson, 1988, as cited in Gifford, 2004, p. 103).

Children need varied experiences of counting. Language is important in helping children assimilate new ideas (Donaldson, 1978, as cited in Gifford, 2004).

We need to make the purpose of mathematical learning explicit and consider when numbers are really relevant for children (Gifford, 2004, p. 106).

Children have their own social purposes for numbers for example for comparison (Carr & Evans, as cited in Gifford, 2004) and may not appreciate the adult’s purpose for number (Munn, 1994, as cited in Gifford, 2004, p. 106).

While children learn math by touching and moving concrete objects they also need to think and make connections about the ideas in math between the concrete and the abstract (Samara & Clements, 2009 p. 66).
Patterning

Humans have a propensity to look for patterns. This is considered a pre-algebraic stage.

In their play children may explore creating patterns with materials. It is important to provide materials that lend themselves to sorting in this way. Young children will focus on one attribute of an object, perhaps the colour and may, while stringing beads for example, organize them according to colour e.g. one blue, one red, one blue, one red etc.

It is important to build on this using mathematically accurate terms. “Can you tell me about how you chose the beads for your necklace?” If the child is not yet able to describe what they did the educator may wish to describe the pattern for them. “I noticed that you have made a pattern with the beads. You used one blue bead and then a red bead, and then a blue bead and then another red bead. We call that a pattern and it reminds me of the stripes on your shirt that are white and green, white and green”.

It is important to provide materials that allow for patterns to extend as opposed to workbooks that provide a small space to identify the next object in the pattern. This can be intimidating for young children who may feel constrained by this format. I have also witnessed that children may change the pattern after awhile. Using open ended materials allows them to experiment in this way.

Children often understand the pattern of the routines of each day “get up, breakfast, go to day care, play, snack, circle, outdoors, lunch, sleep, snack, outdoors, mummy and daddy come to pick me up, go home, dinner, bath, bed”. This is repeated everyday and forms a pattern. This is predictable and comforting for young children. I have experienced young children wanting to go over this pattern to help them understand and predict what happens next and to reassure them that their parents always return to pick them up.

As development progresses children come to understand that a pattern has a core that is repeated to form a pattern

A pattern can be expressed mathematically, a AB AB AB or ABC ABC ABC and this expression can be applied to other situations. The mathematica expression of the stripes on a zebra (AB AB AB) can also describe a pattern in music.

There are also growing patterns and examples of them in children’s literature e.g. Eric Carl’s Today is Monday string beans...as the book progresses repeating the menu for each day while adding on the next day. This pattern can be illustrated using food items cut from grocery flyer.

Measurement

Preschoolers know that continuous attributes such as mass, length and weight exist but do not know how to measure them accurately. At three years of age children know that if they have
some clay and are given more clay they will have more, but they lack the skill and experience to say which of the two amounts of clay is bigger. If one amount of clay is rolled into a long snake the young child will say that is more clay. Learning about measurement helps to develop other areas of mathematics such as reasoning and logic and ties together the two most important domains of early mathematics, geometry and number. (Clements & Samara, 2009, p. 163) Counting involves discrete quantity (use whole numbers to determine how many in a set) and measurement involves continuous quantities with amounts that can always be further divided in smaller amounts (Clements & Samara, 2009, p. 163).

Essentially measuring involves covering space and quantifying that covering (Samara & Clements, 2009, p. 274). Measuring length involves determining the end points of an object and quantifying how far it is between those points. (Clements & Samara, 2009, p. 164)

In their play preschool children frequently make references to measuring. They are interested in whose block tower is taller, which child is the tallest, how heavy an object is etc. Until they have developed an understanding of number, using units to describe how tall an object or person is may not be very meaningful. If you do not understand that 35 is bigger than 27 then using numbers in the measurement of objects is meaningless. However, it is critical to build on children’s interests and understanding.

In the early stages of development children are using their visual/spatial sense to recognize that one object takes up more space than the other object. They are often interested in linear measurement.

Children use the following standards when judging size first is perceptual in which the object is compared to another object that is present. Normative refers to where an object is compared to a standard stored in memory such as an elephant is a large animal and functional, for example, will this shoe fit my foot? (Ebeling & Gelman, 1988, as cited in Samara & Clements, 2009, p. 274)

Children need practice in putting a number with a selected unit of measurement. They need to develop the understanding that the unit of measurement can be standard i.e. centimeters or non-standard e.g. marshmallows, but for measurement to be accurate those units need to be uniform. When we measure we place the units end to end with no spaces in between and count them. At first children may leave gaps between units or overlap the units (Clements & Samara, 2009, p. 165).

Eventually children come to understand that the length of a small unit, such as a block is part of the length of the object being measured. Children need to understand that measurement involves placing the small block repeatedly along the length of object being measured, in other words, tiling the length with no gaps or overlaps and then counting these iterations (Samara & Clements, 2009, p. 276). This is closely related to the understanding of equal partitioning so children can see the need for identical units.
The concept of inversion can be challenging for young children to grasp at first. This is the understanding that it takes fewer of a larger unit to measure something and more of a smaller unit. This can confuse young children because they associate big with more and small with less (Samara & Clements, 2009, p. 278).

What children need...

Many opportunities to practice

Access to accurate mathematical tools e.g., measuring cups in sensory bins, measuring tapes in dramatic play areas e.g. a doctor’s office.

Hearing accurate mathematical language about issues related to measurement. “Oh, dear, this ball is small I did not expect it to be so heavy”.

Teachers can literature to explore concepts e.g., Actual Size books by Steve Jenkins.

Data management/probability

Evidence of children’s early exploration of this stand of mathematics usually involve sorting and classifying objects. This is often observed during their play. The child will select an attribute e.g. colour, size, type and sort the object according to their ‘rule’. As understanding of number and managing data it is possible to conduct simple surveys with children. The process involves selecting a question, “What is your favourite colour?” A population or sample is selected e.g. the entire class. Each person is asked and data is collected. It is then organized to make it easier to understand e.g. bar chart, pie chart. Using their spatial sense children will recognize that the tallest bar or section of a chart means it is ‘bigger’. They may not yet interpret this as a tally of the individual votes e.g. 10 votes compared to 2 votes. It is important to explain what it means. Children will often refer to the most commonly occurring as ‘winning’. Explain the results in simple language. “In this group the most common favourite colour was red” or “More people in this group liked the colour red than any other colour. It is the most popular choice”. Poll another group and see if the results are the same.

On more that one occasion I have observed older preschoolers conduct their own survey. Two of these involved finding out how old children were. In both cases the children created a chart with columns for the different ages, asked each child present how old they were and made a tally of the results. The children had a question they wanted the answer to, they had the mathematical tools to conduct a survey and they did so.

Older preschoolers love to do surveys and they can become part of a circle time activity, for example, favourite colours.
**Probability**

Regarding probability at this stage of development the most appropriate approach is to use the language associated with probability so that children become familiar with it. Discuss such this as it something possible, impossible, likely, certain etc.

Again, children’s literature e.g. authors such as Robert Munsch, provides many examples to provoke conversations about probability. “What are the chances something like this could really happen?”

**Geometry**

This strand is the oldest area of mathematics and literally means ‘measure the earth’. It includes spatial awareness, describing positions and the properties of two and three dimensional shape. In 1986 the Van Hieles developed a model to describe the stages of the development in the understanding of geometry (Samara & Clements, 2009, p. 206). The research in this area of children’s mathematical development is less developed than for number (National Research Council, 2009, pp. 6–23).

There is evidence that infants have some sensitivity to area in the first year of life (Xu & Spelke, 2000, as cited in Samara & Clements, 2009, p. 293).

Children begin by recognizing shapes as wholes and not defining them by their attributes or properties. (Clements & Samara, 2009, p. 124) Children learn their properties through observing, drawing, measuring and making models (Clements & Samara, 2009, p. 124).

Circles are the easiest shape to identify. There is just one type and they can only vary in size. 92% of four year olds to 99% of 6 year olds could accurately identify circles. circles were easily identified, but children found them difficult to describe with a few children describing them as “round” (Clements & Samara, 2009, p. 128).

Squares were the next and less accurate were rectangles and triangles. Children show interest and involvement with “pattern and shape” more frequently than other categories. This included recognizing, sorting and naming shapes.

Also are examples of symmetry, congruence and transformations in children’s play (Clements & Samara, 2009, p. 128). They also produce symmetry in their play.

*What children need...*

Access to many types of building materials, wooden blocks of various sizes, Lego, Trio blocks etc.
We tend to present very rigid examples of shape to children. We know that often young children astound us with their ability to pronounce the names of a dozen dinosaurs. If young children can say and understand the names of dinosaurs they can do the same for octagon and hexagon. solids, cubes, cylinders.

We need to provide examples of irregular shaped polygons and not just always regular ones.

We can introduce children to the concept of shapes having angles that can be measured.

Teachers provide experiences with two dimensional shape we need to provide children with more experiences with three dimensional solids. For example, making cubes from a net.

By asking well thought out questions we can gain a better understanding of children’s thinking. We can ask them how they know an object is shaped like a triangle and witness their definition.