5-2015

The Language of Mathematics: Early Childhood Mathematics for Children who are Deaf or Hard-of-Hearing and the Role of Parental Involvement

Alexandra Carlton
Utah State University

The Language of Mathematics: Early Childhood Mathematics for Children who are Deaf or Hard-of-Hearing and the Role of Parental Involvement

by

Alexandra Carlton

A project submitted in partial fulfillment of the requirements for the degree of

MASTER OF EDUCATION

In

Communicative Disorders and Deaf Education

Defense Approved:

_____	_____
Lauri Nelson, Ph.D. Major Professor	Elizabeth Parker, M.Ed. Committee Member
_____	_____
Sonia Manuel-DuPont, Ph.D. Committee Member	Judith S. Sexton M.S., C.E.D., LSLS Cert. AVEd. Invited Member

Utah State University

2015

Introduction

The development of the Common Core Standards sought to guide educators across the nation in providing commensurate academic programs and to define what students should know for career and college readiness. As of August 2013, forty-three states, the District of Columbia and four territories had adopted the Common Core Standards for grades kindergarten through twelve in the areas of English language arts and mathematics (National Association for the Education of Young Children [NAEYC], 2012; National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010; Race to the Top Fund, 2014). To ensure kindergarten readiness, rigorous early childhood education must be implemented to optimize the success in the K-12 setting. The effect of directed teaching in the early childhood years is being studied by the National Association for the Education of Young Children (NAEYC). In a 2012 position statement, NAEYC suggested two areas of concern:

> First, the application of the Common Core to K-3 overlaps with NAEYC's interest in the latter years of early childhood during which children enter school and progress through the early elementary grades. For these children, the development and implementation of the Common Core will have a direct and immediate impact. Second, there is the potential for the Common Core to impact programs for young children prior to kindergarten entry. Together, these two systems capture the early years of children's continuum of learning. (NAEYC, 2012, p. 3)

Children in early childhood programs across the nation are expected to master skills across the academic domain prior to kindergarten entry. In the area of mathematics, concepts such as numbers, geometry, and measurement are pivotal skills, as identified by the National

Council of Teachers of Mathematics (NCTM). The acquisition of these mathematic concepts should be explored in meaningful ways to promote opportunities for young learners to make real life connections.

However, limited empirical research is available that explores the impact of utilizing the Common Core Standards, to guide and document kindergarten readiness, in children who are deaf or hard of hearing. Specifically, parental involvement with language-based mathematics experiences, including comparing and contrasting data sets and gaining meaning from word problems, in the context of the home environment, requires more thorough research as preschool-age children with hearing loss enter mainstream classrooms. For example, an age-appropriate expectation for a preschool-age child to compare and contrast a data set might include the ability to use tools such as measuring cups, to describe quantities of objects or generate graphs, with adult support, regarding data about favorite colors or animals. A child might gain meaning from word problems by engaging in games, in which he or she listens to a number story and derives the remaining quantity of items if an item is added or taken away (Sally has two apples. How many apples will she have if I give her one more?) With appropriate supports, parents can promote development of these skills utilizing authentic experiences in the home environment consistent with those of their hearing peers and as described in the Common Core Standards for kindergarten readiness.

Empirical data regarding the performance of preschool-age children with hearing loss in language-based mathematics development and the impact of parental involvement in development of math skills would contribute to evidence-based recommendations for parents to support their child's academic achievement.

The proposed project will include development of materials for parents to utilize within the home environment to support language-based mathematics development in their preschool child with hearing loss. The project will also obtain parent feedback describing the usefulness of the materials and the perceived impact on their child's mathematic growth. Materials will be developed in alignment with the Common Core State Standards for kindergarten readiness. Upon project completion, a protocol to encourage parents to become partners in preparing their children with hearing loss to enter mainstream classrooms with skills commensurate to their typically hearing peers will be provided. Furthermore, descriptive data concerning parent's perception of the benefits of utilizing at-home materials will be evaluated utilizing survey and narrative data completed by parents.

National and State Early Childhood Standards and Early Learning Recommendations

The NCTM developed core content areas to better prepare young children for kindergarten entry, as shown in Table 1:

Table 1.

National Council of Teachers of Mathematics Core Content

Numbers and Operations	• Recognize numbers • Count, using rote method and one to one correspondence • Compare
Geometry	• Recognize shapes • Describe spatial relationships
Measurement	• Identify measurable attributes • Compare and contrast objects

To further compare state-level recommendations with those of the NCTM, and to identify commonalities between two states, the Pennsylvania Core Standards (see Table 2) and Utah's Early Childhood Core Standards (see Table 3) were evaluated. Both Pennsylvania and Utah are among the states that have adopted the Common Core Standards. The current Pennsylvania standards were revised in 2014 and the Utah standards were adopted in 2011.

Table 2.

Pennsylvania Core Standards: Mathematics

Numbers and Operations	CC.2.1.PREK.A.1: Know number names and the count sequence CC.2.1.PREK.A.2: Count to tell the number of objects CC.2.1.PREK.A.3: Compare numbers
Algebraic Concepts	CC.2.2.PREK.A.1: Understand addition as putting together and adding to, and understand subtraction as taking apart and taking from
Geometry	CC.2.3.PREK.A.1: Identify and describe shapes CC.2.3.PREK.A.2: Analyze, compare, create and compose shapes
Measurement, Data and Probability	CC.2.4.PREK.A.1: Describe and compare measurable attributes of length and weight of everyday objects CC.2.4.PREK.A.4: Classify objects and count the number of objects in each category

Table 3.

Utah's Early Childhood Core Standards

Counting and Cardinality	**Know Number Names and Count Sequence** 2. In the sequence of 1-10, understand that numbers come before or after one another 3. Count a number of objects 0-10 and associate with a written numeral **Count to Tell the Number of Objects** 4. Understand the relationship between numbers and quantities; connect counting to cardinality **Compare Numbers** 6. With modeling and support, identify whether the number of objects in one group is greater than, less than or equal to the

	number of objects in another group 7. Associate quantities with written numerals 1-10
Operations and Algebraic Thinking	**Understand Addition as Putting Together and Adding to, and Understand Subtraction as Taking Apart and Taking from** 6. Duplicate, extend and create simple patterns
Number and Operations in Base Ten	N/A
Measurement and Data	**Measurement and Data** **Describe and Compare Measurable Attributes** 1. Describe objects using vocabulary specific to measurable attributes 2. Compare objects using measurable attributes **Classify Objects and Count the Number of Objects in each Category** 3. Classify objects into given categories; count the number of objects in each category and sort the categories by count
Geometry	**Analyze, Compare, Create and Compose Shapes** 4. With prompting and support, describe basic two and three-dimensional shapes

Although fundamentally similar, the states vary in their organization, content and delineation of standards. The Pennsylvania Early Learning standards and the Utah core standards each designate skill acquisition within three age ranges: infant-toddler, pre-kindergarten and kindergarten. This project will focus on the pre-kindergarten standards. Each standard statement is divided into a 'big question' and essential questions. Standards are to be implemented within the child's natural learning environment, including direct mathematics instruction, language learning, science exploration and free play activities. Within the standard statement are goals, examples of activities and supportive practices to use at school and as home carryover.

Recommendations for Teachers to Deliver Effective Language-Based Mathematics Instruction

Recognizing the benefits of implementing effective mathematic instruction in the early childhood setting, NAEYC and NCTM developed a joint position statement in 2002. Outlined in the statements are ten principles for best practice in mathematics education (National Association for the Education of Young Children [NAEYC] & National Council of Teachers of Mathematics [NCTM], 2002, p. 3):

1. Enhance children's natural interest in mathematics and their disposition to use it to make sense of their physical and social worlds.
2. Build on children's experience and knowledge, including their family, linguistic, cultural, and community backgrounds; their individual approaches to learning; and their informal knowledge
3. Base mathematics teaching and curriculum practices on knowledge of young children's cognitive, linguistic, physical, and social-emotional development
4. Use curriculum and teaching practices that strengthen children's problem-solving and reasoning processes as well as representing, communicating, and connecting mathematical ideas
5. Ensure the curriculum is coherent and compatible with known relationships and sequences of important mathematical ideas
6. Provide for children's deep and sustained interaction with key mathematical ideas
7. Integrate mathematics with other activities and other activities with mathematics
8. Provide ample time, materials, and teacher support for children to engage in play, a context in which they explore and manipulate mathematical ideas with keen interest
9. Actively introduce mathematical concepts, methods, and language through a range of appropriate experiences and teaching strategies
10. Support children's learning by thoughtfully and continually assessing all children's mathematical knowledge, skills and strategies

From a young age, children have a natural inclination towards mathematics (NAEYC & NCTM, 2002). Counting blocks, comparing quantities of snack, identifying shapes in the environment or creating a height measurement chart are all typical activities in a preschool day. Both NAEYC and NCTM agree that capitalizing on these early experiences creates a positive outlook on mathematic learning in young children. By creating varied experiences, young learners are able to explore concepts in an assortment of mediums, including visual, auditory and tactile (Hachey, 2013; Purpura, Hume, Sims, & Lonigan, 2011). All curricula should be based in best practice across developmental domains, including cognition, communication, social-

emotional, physical and adaptive. Recognizing the stages of early childhood development, teachers can implement activities that challenge students, but do not push them to the point of frustration.

Math in Preschool Daily Routines

Curriculum and instruction should be rooted in the background knowledge of children, appropriate for their age, experience and comprehension of mathematics concepts (NAEYC & NCTM, 2002). By developing problem solving skills early, children can apply mathematics to other curricular areas. Moreover, in making connections between subject matter, children build their knowledge in all areas of instruction. Curricula must be sequenced to target instruction so that the child ultimately comprehends the 'big picture.' Mathematic instruction should be a purposeful part of the early childhood day (Hachey, 2013).

Mathematics instruction should be incorporated throughout a child's daily routines, rather than at one set time during the day. Everyday activities, such as comparing the number of children who are present versus absent, promote development of mathematical concepts. Incorporating mathematics into other subject areas provides cross-curricular instruction. In the reading corner, books with mathematic themes can be displayed. During a science activity, students can measure the growth of a plant or identify volume by pouring objects from one container to another. With limited time in the early childhood classroom, cross-curricular activities serve to allow exploration of several content areas. Free play can also provide opportunities for mathematic learning. By setting aside planned manipulatives and materials, children can engage in problem solving routines. Additionally, classroom staples, such as a

block center, allow for mathematical planning. For example, students must determine how blocks are placed to be structurally sound.

When introducing new concepts, the joint position statement recommends bridging new knowledge with familiar themes as well as developing meaningful and engaging ways to gain student attention. In addition to natural exploration, purposeful planning is an important component to mathematics education. Allowing time for small group work to observe student problem solving skills and gain understanding of individual comprehension is of equal importance (NAEYC & NCTM, 2002).

Young children learn through play (Hachey, 2013; NAEYC & NCTM, 2002). Problem solving can be supported during play routines, including use of one object to represent another, recognizing letters, numbers and symbols in the environment and asking a variety of open ended questions (Office of Child Development and Early Learning [OCDEL], 2009). For example, a block can be used as a pretend telephone, letters are observed on pretend food labels, and questions are used to further engage in conversation regarding the environment. Children can also express mathematical ideas through drawing and emerging writing. Through use of authentic and naturally occurring activities, children can express complex mathematical ideas. Communication skills are necessary in conversing mathematical ideas through play.

Math Instruction and Assessment

Through careful planning, meaningful math experiences take place in the classroom. However, to ensure student progress, authentic assessments must occur. According to the joint commission statement, "Child observation, documentation of children's talk, interviews, collection of children's work over time, and the use of open ended questions and appropriate

performance assessments to illuminate children's thinking are positive approaches to assessing mathematical strengths and needs." (NAEYC & NCTM, 2002, p. 9) By creating positive, purposeful mathematics experiences, young children take advantage of their natural interests and engage in meaningful learning (Howell & Kemp, 2010).

According to the Educator's Practice Guide, *Teaching Math to Young Children* (2013), three common themes should direct teachers in providing high quality mathematics instructions. Similar to the NAEYC and NCTM joint position statement, it is recommended that mathematics instruction occur across multiple content areas. This permits students to make meaningful, cross-curricular connections and further stimulate mathematical thinking that will be pertinent in later years (Skwarchuk, 2009). Developmental progression is critical in teaching mathematics, recognizing that linguistic and foundational mathematic concepts and skills build upon one another.

Preschool Performance Expectations

Mathematics engagement occurs inherently within the preschool environment. By capitalizing on a child's natural interest in mathematics, preschool classrooms can embed strategies to facilitate learning during structured and unstructured activities. Frye, Baroody, Burchinal, Carver, Jordan, & McDowell (2013) outlined five recommendations for meaningful mathematics interaction in early childhood education. These recommendations included teaching numbers, operations, geometry, patterns, measurement and data analysis using developmental progression, monitoring progress, describing the world using mathematical terms and incorporating meaningful mathematic instruction periods during the early childhood day (Frye et al., 2013). Within each identified domain, a progression of skills is necessary to reach

comprehension. The progression for teaching numbers and operations delineates the steps from early number skills to more complex skills, such as operations. Subitizing refers to a child's ability to recognize the number of objects within a closed set. Through glance a child should recognize items in sets of one, two and three, such as one nose, two eyes or three blocks. Meaningful object counting refers to counting using a one-to-one correspondence. Counting based comparisons requires children to recognize sets of numbers to determine which has more or less. Recognizing which number comes next in any given sequence is considered 'number after' knowledge. Comparing numbers allows children to mentally determine if a number has a value greater or less than another. The last skill outlined in the progression is the ability to recognize the number following a number has a value of one more (Howell & Kemp, 2010; Swarchuk, 2009).

To establish foundations of geometric concepts, children must first gain recognition of basic shapes. Identifying and comparing shapes can occur throughout a child's day by looking for shapes in the classroom, creating shapes in drawings and playing with blocks. Shapes can also be combined to create new shapes. Patterning occurs next in the geometric developmental progression. Children are expected to recognize, extend and ultimately create patterns. Measurement in the classroom should occur using standard and non-standard forms. Yard sticks, rulers and measuring tapes constitute standard forms of measurement. Using handprints or yarn allows students to measure using non-standard forms (Frye et al., 2013).

By kindergarten, it is anticipated that children should be able to count by rote to twenty. Although counting requires this computational knowledge, a great deal of language input is necessary to fully develop this skill. Counting songs can be taught in school. Similarly, books that incorporate counting can be read in the classroom. The use of ordinal numbers, such as first,

second and third, is also anticipated at kindergarten entry. When reading with children, teachers can sequence the events of a story using this vocabulary. Number sentences can be used to describe counting and grouping objects. According to *Teaching Math to Young Children* (2013), students must have a firm understanding of computation that is counting groups of objects, before they can begin more complex problem solving.

Mathematics Standards at School and at Home

Measurement can occur using both standard and non-standard forms. Standard units may include U.S. standard units or the metric system. Non-standard forms, however, encompass a variety of manipulatives, such as unifix cubes, yarn or footprints. In addition to using measurement to determine length, this standard also includes telling time, measuring temperature, and recognizing day versus night. At home, parents can support measuring activities by tracking a height chart, monitoring temperature changes and talking about times of day. Tools around the home to support this domain include a bathroom scale, analog clock, timer, rulers, and tape measures (Utah State Office of Education, 2013). Furthermore, in meal preparation, children can determine the containers necessary to hold quantities of liquid. Comparative language is also necessitated in determining if objects are bigger or smaller and warmer or cooler than one another (Hachey, 2013).

The Correlation between Math and Reading Achievement

Through meaningful and authentic experiences, including reading, story time, and grapheme exploration, children gain exposure to literacy concepts including phonological processing and recognition of print (Howell & Kemp, 2010; Purpura et al., 2011). In the area of mathematics, counting and comparing numbers, occur naturally throughout the day (Hachey,

2013). For consequential mathematical exploration, children must have a firm foundation in language based competencies.

> Much of the application of mathematical knowledge to basic computational and comparative skills is inherently dependent on children's understanding of language. For example, language skills may be important for understanding the concepts of ''more'' and ''less'' as well as understanding that a range of mathematical words can mean the same thing and can often be used interchangeably (e.g., plus, and, add, together). These language-related mathematics terms are often found in mathematics assessments, interventions, and curricula. (Purpura et al., 2011, p. 649)

Math Development and Phonological Awareness

Skills associated with reading and mathematics demonstrate a high correlation in the preschool years. Specifically, phonological awareness is shown to be directly related to mathematics development and is predictive of early numeracy development (Purpura et al., 2011). Through use of norm-referenced tests, including the Preschool Early Numeracy Skills (PENS), Woodcock-Johnson III, Test of Preschool Early Literacy Skills (TOPELS) and the Stanford-Binet, the correlation between literacy and numeracy was supported in typically developing preschool children, aged three to five. Early literacy skills, including vocabulary, print knowledge and initial phonological awareness, are predicative of numeracy skills. Language is linked to learning vocabulary terms associated with mathematical concepts. Word problems present the need for comprehension skills in solving computational problems (Purpura et al., 2011).

Books, such as Five Little Monkeys Jumping on the Bed (Christelow, 1989), or songs, such as Five Speckled Frogs, support the concepts of adding and taking away objects (Utah State Office of Education, 2013). Early literacy skills, including oral language, phonological processing and print knowledge, closely correlate to early numeracy development (Purpura et al., 2011).

Math Development, Vocabulary, and Syntax

Computational skills, in early childhood mathematics, including counting, measurement and emergent algebraic and geometric thinking, can be accomplished through rote ability (NAEYC & NCTM, 2002). However, language-based components exist within these core features. As students count numbers, comparisons of quantities occur. To do so, comprehension of vocabulary, including greater than and less than, must be obtained. Use of the comparative grammatical marker, -er, must also be achieved. Students are anticipated to identify and compare quantities of manipulatives, differentiate between letters and numerals, use ordinal words to describe position of objects and solve word problems about concrete objects. In using ordinal words, such as first, second and third, students must have developed syntactical skills, recognizing order of events. Within measurement, students are expected to measure using standards and non-standard forms and quantify findings by attribute, respond to questions including 'how many' and 'how much' and apply vocabulary in accordance to standard forms of measurement. Furthermore, in interactions with teachers, peers and parents, communication of mathematical concepts is projected (Skwarchuk, 2009). Although founded through computational knowledge, these complex skills require an age appropriate level of language development to include comprehension of complex questions, expanded vocabulary and ability to engage in conversational turns (OCDEL, 2009; Utah State Office of Education, 2013).

During the early childhood day, children receive both structured and unstructured opportunities to learn. Direct instruction often emphasizes language and literacy. However, children have a natural inclination towards mathematics (Hachey, 2013; NAEYC & NCTM, 2002). Children quantify amounts at snack time. Shapes appear naturally, in traffic signs, blocks and classroom materials. Attributes are used to describe aspects of the day. By making this an active part of the early childhood day, teachers are capitalizing on this natural interest and enacting higher level thinking skills (Hachey, 2013). According to Howell and Kemp (2010), a greater emphasis on computational math skills is placed in the early childhood years. Although children can count a group of objects, the ability to quantify and describe that set proves challenging. Mathematical vocabulary and understanding of syntax, including order of events, is necessary for young children to communicate about the world around them.

Howell and Kemp (2010) evaluated if receptive vocabulary and mathematical skills are components of "number sense", and if they are predicative of future mathematical struggles. They sought to determine the percentage of children who demonstrate "number sense," and if a difference existed between receptive vocabulary and mathematics skills by gender or childcare settings. Study results indicated a relationship existed between early “number sense”, meaning comprehension of numbers, value and counting, and later mathematic performance. For kindergarten entry, language skills are needed to support mathematical thinking and problem solving. In teaching mathematics, a variety of strategies are needed to reach the unique needs of learners. Early mathematics comprehension is indicative of future success. Utilizing a range of teaching methods to engage students in mathematics experiences so that they can be challenged just about their present level of function is recommended (NAEYC & NCTM, 2002; Skwarchuk, 2009).

Parents as Partners in Early Childhood Education

Preschool children spend a small portion of their day in formal academic programs. The remaining time is spent at home, with parents, siblings and other caregivers. Building upon parents as a child's first and natural teacher is a critical component in early childhood education (Skwarchuk, 2009). Although families are advised to regularly read with their children, a variety of mathematic opportunities exist within the home. Skwarchuk (2009) explored parental anxiety level towards mathematics and the relationship between parental participation in early childhood mathematic learning. Parents in the study were asked to keep diaries, outlining their thoughts and experiences regarding mathematical exchanges with their child. Families completed a questionnaire comprised of five sections. Within the questionnaire, demographic information was ascertained, mathematic experience was assessed, opinions on promoting mathematic activities were analyzed and frequency of mathematic learning in the home was determined. Each participant was given a bag of activities to be used in ten to fifteen minute increments and subsequently documented. A video-taped session of family participation in supplied activities was conducted in a laboratory-setting. Finally, participants were assessed using the Quantitative Concepts subtest of the Woodcock Johnson Tests of Achievement. Skwarchuk reported parental predispositions towards mathematics subsequently can carry over to interactions with their child. Negative feelings towards mathematics led to limited incorporation of these skills into daily routines. Conversely, parents with positive sentiments towards the subject engaged in more meaningful exchanges. Given resources, to be used at home, parents helped to increase their child's score on numeracy based standardized assessments. Furthermore, parents recognized opportunities to incorporate mathematics learning into preschool play.

Parental involvement for children with hearing loss in early mathematical development was studied by Kritzer and Pagliaro (2013). This study explored parental understanding of mathematics when interacting with their child with hearing loss and the degree to which parental involvement in the Mathematics Readiness Parents as Partners (MRPP) program affected parent-child interactions. Six children, ages three to five years, and their families participated in the MRPP program. Families were required to attend five workshops over the course of the year focused on mathematical concepts, including categorizations and sequencing, measuring and spatial sense, problem solving and number, and shapes and orientation, subsequently reviewing previous material and incorporating math naturally within a child's day (Kritzer & Pagliaro, 2013). Video-taped sessions of parent-child interactions were recorded before each workshop and one at the end of the intervention period. Sessions were taped during natural activities, such as cooking, mealtime or dressing routines. Parents were also required to journal their impressions and findings throughout the study. Results of the study indicated the type of language that families used with their child with hearing loss changed over the course of the year. Initially, families most commonly utilized number-related mathematical concepts throughout their day. However, at the end of the study, families incorporated geometry and measurement concepts regularly throughout natural activities, due to increased awareness of higher level concepts as well as mediation skills fostered throughout the project. The study also found parents engaged their child in higher level thinking skills. Parent attitude towards mathematics also progressed. Participating in the MRPP program demonstrated a positive impact on parental incorporation of higher level mathematical concepts within daily routines (Kritzer & Pagliaro, 2013). With coaching and guidance, parents incorporated more complex mathematical concepts into their child's day. Natural incorporation of mathematical concepts,

embedded within daily routines, allows for children to obtain greater knowledge in areas including numbers and operations, algebraic thinking, measurement and data collection and geometry.

Math Skills in Children who are Deaf and Hard of Hearing

Historically, children with hearing loss have been shown to lag behind their typically hearing peers in mathematics performance (Nunes & Moreno, 2002; Pagliaro & Kritzer, 2013). Two hypotheses exist as to what causes this gap. First, children with hearing loss may struggle in the classroom to follow presentations of abstract concepts. The second is that challenges occur before the child enters formal schooling (Zarfaty, Nunes, & Bryant, 2004). Zarfaty et al. (2004) explored if mathematics deficits in children with hearing loss could be traced to early childhood education and if their concepts of numbers vary from those of hearing peers. In the study, twenty children, between the ages of thirty-one and fifty-four months, were assessed. Ten children with hearing loss were paired with ten children with typical hearing. The children with hearing loss were placed in a program emphasizing the use of listening and spoken language. The typically hearing children attended a preschool program that followed a similar curriculum. The children were given prompts on a computer screen regarding configuration of blocks. After viewing the prompts, the children were directed to a table of blocks and were encouraged to reproduce what was on the screen. Two conditions were tested, spatial and temporal. Study results indicated that children with hearing loss were not at a disadvantage to their typically hearing peers in the area of number discrimination. Young children with hearing loss, in the study group, did not struggle in number representations, as compared to their typically hearing peers. Spatial representations, however, may better benefit children with hearing loss in representing mathematical concepts (Zarfaty et al., 2004).

To determine a 'math gap' between children with hearing loss and their typically hearing peers standardized assessment, specifically the Test of Early Mathematics Ability (TEMA-3), and Performance Based Tasks (PBT) were utilized with twenty children with hearing loss, from ages three to five (Pagliaro & Kritzer, 2013). Testing was conducted one on one in the family's home. The performance based tasks addressed numbers and operations, geometry, measurement, problem-solving and patterning. Tasks were rated as "low," "middle" and "high." The level of assistance was also noted on performance based tasks as "unassisted," "guidance" and "modeling." Results indicated that children with hearing loss often do not have skills comparable to their typically hearing peers, as defined by mathematics common core standards. Geometry was noted as an area of strength in children with hearing loss (Pagliaro & Kritzer, 2013). Areas of weakness were noted as problem solving and measurement (Pagliaro & Kritzer, 2013). Because early exposure to concepts of "number sense" promotes development of higher mathematical thinking (Howell and Kemp, 2010), results suggest introducing children with hearing loss to meaningful mathematics opportunities, subsequently fostering higher level thinking skills, will better prepare them for mathematics learning (Pagliaro & Kritzer, 2013; Krtizer & Pagliaro, 2013).

Collaboration Between Parents and Teachers

Young children learn through authentic experiences both in and out of school (Kritzer & Pagliaro, 2013; NAEYC & NCTM, 2002; Skwarchuk, 2009). Through the guidance of the state standards, teachers implement curricula to improve academic skills. Within a typical preschool day, students experience literacy and language based activities, mathematics instruction, science exploration, as well as music and art. Parents, however, can carryover such activities within daily routines at home (Skwarchuk, 2009). Collaboration between teachers and parents leads to

better opportunities to practice and generalize academic skills taught in the classroom. Mathematics can be used to describe phenomena at home, in the classroom and across other settings encountered by preschool children (Hachey, 2013).

Project Summary

Project Overview

This educational project proposed to examine the Common Core Standards, as related to mathematics development, in the early childhood curriculum, specifically highlighting the skills necessary for kindergarten readiness. In identifying best practices, the project sought to highlight how parental involvement may impact early mathematics education. Furthermore, with advances in hearing technology, children who are deaf and hard of hearing are entering mainstream classrooms. To support the unique needs of these learners, feedback was necessary to identify strengths and weaknesses in mathematics education with this population of students. Implementations of additional support systems, such as resources for parent involvement, were proposed to foster mathematics learning.

Project Goals

1. To develop home based materials that compliment mathematic skill development as aligned with the early childhood common core standards for kindergarten readiness.
2. To identify the impact of parent involvement in home-based mathematic instruction of children with hearing loss as measured through use of narrative feedback.

Participants and Sampling

Children with hearing loss, utilizing listening and spoken language as their communication modality, between the ages of four and five and preparing for kindergarten entry participated in the project. Parents and teachers from Clarke Schools for Hearing and Speech, Pennsylvania received project materials and completed the feedback form. Project materials, including instructional handouts, manipulatives and feedback forms, were shared with families, guiding them through units of instruction in the area of language-based mathematics.

Materials

Informed consent form. Informed consent was obtained through use of a letter of information, outlining the project. This letter sought to guide families in addressing project goals as well as speak to future implications of the project, including the development of a protocol encouraging parents as partners in early mathematics education.

Lesson plans. Lesson plans accompanied each unit, outlining material usage, in parent friendly terms, so that families could implement resources in the designated fashion. In addition to lesson plans, feedback forms followed each unit. Families supplied narrative data on the readability of lessons as well as child participation. Rating scales were also utilized to obtain qualitative data.

Binder. Materials were arranged in a binder, by unit. Each unit contained an introductory letter, outlining the content area. Lesson plans, highlighting the intended goal and targeted vocabulary were supplied. Furthermore, lesson plans included step-by-step instruction to implement unit materials in both direct instruction settings as well as incorporated throughout daily routines. Binder contents also included materials specific to the unit, including targeted books and manipulatives to support skill development.

Areas of instruction focused on the language-based components of the following subject matters:

Numbers and Operations

In identifying the language based components of counting and cardinality, books and songs were supplemented with props. Participants were expected to utilize materials in counting backwards from five and ten. Furthermore, participants were encouraged to match numerals to a

set of objects. Counting and comparing numbers was reinforced through block play and turn-taking games.

The book, *Ten Fat Turkeys*, by Tony Johnston, was used to support literacy within the unit, Numbers and Operations. Families were encouraged to read the book with their child. Before reading, it was suggested that families identify both the author and illustrator of the book. Additionally, it was recommended that families take a "picture walk," so that their children could make predictions and comments about the book. To promote counting, using a one-to-one correspondence, it was anticipated that children could count the number of turkeys on each page. This story also promotes the concept of subtraction, as turkeys are removed as the book progresses. Ten turkey cut outs were supplied so that families could recreate the story. It was expected that families would count the ten turkeys. After the turkeys had been quantified, families were asked to remove one, two or three turkeys, posing the question, "How many are left?" This activity focused on number concepts from one to ten, while introducing the concept of subtraction.

To foster skill development in recognizing the names of numbers, counting in sequence and counting using a one to one correspondence, the game, "Clothespin Number Match," was developed. In this activity, children were encouraged to select a clothespin from a pile. Children subsequently had to identify the numeral on the clothespin. Upon identifying the numeral, children were expected to use the number wheel, count the corresponding dots, and match the clothespin to the equivalent location. Extension activities for this lesson included searching for numerals within the child's environment, such as identifying numbers around the house, on signs or in books. The concepts of *before* and *after* were also explored in asking children to identify numbers that occur *before* and *after* in the sequence.

To complete the activity "Roll and Build Block Towers," families were encouraged to roll the accompanying die and count the dots. After identifying the numeral, it was expected that the child count the corresponding number of blocks and stack them. Families were encouraged to take turns rolling the die, asking questions including *how many*, as well as use comparatives, such as *bigger* and *smaller*. The concept of addition was introduced, as families were asked to add blocks to the tower and determine *how many more* were present.

The game, "Playing Card Math," was used to foster number identification, from one to ten, as well as identify numerals as *bigger* or *smaller* in value. Players were to flip a card, identify the numeral and determine which numeral was had the greatest value. The player that flipped the card with the highest value was to keep all of the cards. This sequence continued until one player collected all of the cards. Number sequence was also facilitated by asking all players to identify the number that comes *before* and *after* the card played. Extension activities to continue skill development in this area included counting the steps within the home. Targeted vocabulary comprised of *how many, greatest* and *least*.

Algebraic Concepts

Home-based lessons included sequencing activities. Such activities fostered auditory memory skills by requiring participants to recall a series of actions. Patterning practice occurred through use of stickers. Books were provided to foster sequencing and patterned reading.

Quack and Count, by Keith Baker, was used as a literary source to supplement the concept of addition within this unit. In this book, quantities of seven were promoted through adding. Families were asked to count the number of ducks pictured on each page and create a number sentence to represent the total quantity, such as "I have three ducks. I added four more

ducks. Now, I have seven ducks." Following the story, families were asked to locate items around their house, in quantities of seven. The concepts of creating number sentences were further developed by having family's group items and determine the total number present.

Patterning was used to support auditory memory skills. Families were provided with construction paper and shape stickers. Examples of patterns, including AB, AAB and ABC, were modeled. It was expected that families use the supplied materials to create a border around the construction paper, so that it could ultimately be used as a placemat. Children were expected to identify and describe the rule used to create their pattern. Patterning is not limited to direct instruction activities. Extension suggestions were provided so that families could carry this concept into daily routines. Such activities included patterning shoes and dry pasta noodles. Additionally, gross motor activities were proposed. It was anticipated that children identify the pattern and subsequently extend it.

The Pennsylvania State Standards outline the concepts of addition as "putting together and adding to" and subtraction as "taking apart and taking from." To facilitate these concepts at the preschool level, two activities were developed. "Ladybug Addition" provided families the opportunity to practice adding by placing "spots" on a ladybug. Children were encouraged to identify the number of spots on each side of the ladybug and subsequently identify the total number of spots. To engage families in the concept of subtraction, a bowling game was devised. Families were instructed to use ten paper cups to create bowling pins. Following set up, it was expected that family members take turns rolling the ball to knock down the pins. Number sentences were modeled to represent subtraction, "If there were ten cups, and I hit three, now there are seven cups standing." Vocabulary, including *how many*, *add*, *plus*, *more*, *take away*, *subtract*, *minus*, *less* and *equal*, were promoted.

Measurement, Data and Probability

Non-traditional measuring tools were provided, including string, blocks or shoes so that participants could measure items around the house as well as compare and contrast data. Families were encouraged to complete a height chart to support use of the superlative, -er. Additionally, families utilized materials within their own home to classify based on shape, color or size.

To explore the concepts of weight and comparatives, the book *Balancing Act*, by Ellen Stoll Walsh, was supplied. After reading the accompanying story, families were asked to create a balance scale and weigh items around their house. Materials, including a hanger, yarn and hole punch, were supplied to assist families in creating the scale, however, cups for the scale were not supplied in the kit. Families were encouraged to locate items, around the house, to place in the scale. Just as in the story, families were to balance the scale by placing more items on one side, or removing items from the opposing side. Comparisons were made using the terms *heavier* and *lighter*.

Standard units of measurement are used in cooking. To make play dough, families utilized formal measuring tools. Additionally, new vocabulary was introduced, including *ingredients* and *measuring cup*. Auditory memory skills were fostered by encouraging families to label ingredients and have their child recall all items listed. Furthermore, upon mixing all ingredients, families were instructed to use food color to change the pigment of the play dough. Counting was incorporated by identifying the number of drops utilized. Children were also encouraged to make predictions as to the color of the play dough based on the number of drops consumed and the mixing of food coloring. Extension activities for this concept included exploration of volume using Tupperware containers. Families were encouraged to fill

Tupperware with water and subsequently pour contents from container to container. Containers were to then be organized from *biggest* to *smallest*. In addition to size concept and comparative language, this activity sought to introduce the concept of volume.

Measurement occurs in standard and non-standard forms. Families were supplied with yarn to use as a non-standard form of measurement. Measurement of family members was to take place using the yarn. Following the measurements, the yarn was to be aligned from *tallest* to *shortest*, so that comparisons could be made. To extend this activity, it was recommended families use their own formal height chart that could be referenced throughout the year.

Sorting was used to classify items by a predetermined rule. Beads, varying in size, color and shape were supplied to families. This activity encouraged families to sort by a rule and subsequently have their child identify the rule utilized. The child was also given an opportunity to sort and explain the rule he or she selected. Household items, such as Matchbox cars and pasta noodles, were identified as ways to facilitate sorting throughout daily routines.

Geometry

This standard was fostered through descriptive practices of identifying and describing shapes within the natural environment.

Mouse Shapes, by Ellen Stoll Walsh, served as the literacy connection for this unit. Shapes identified included *square*, *circle*, *diamond*, *rectangle*, *oval* and *triangle*. In this book, shapes were manipulated to create varying images. Following reading, families were encouraged to use the supplied shape die by rolling the die, identifying the shape, and graphing the results. The graph was subsequently used to identify the number of times a shape was rolled as well as expand the concepts of *most* versus *least*.

Shapes can be viewed as items around the house and within the community. In the activity, "Shape Scavenger Hunt," families were supplied a hand out in which they could draw shapes located in their environment. Suggestions were provided to guide the scavenger hunt around the house. Comparisons occurred by having families identify which shape was viewed the most versus least. It was also recommended that families play the game, "I Spy..." to further facilitate the identification of shapes.

The activity, "Pattern Block Creations," allowed families to manipulate shapes to create images including a boat, train, car and house. Furthermore, location vocabulary was highlighted, as families were encouraged to give directions to recreate images using words such as *next to*, *above* and *below*. To facilitate carryover of skills, suggestions were provided using building blocks to create towers or castles. In completing this activity, children were anticipated to recognize shapes, count the number of sides and follow directions regarding location.

Dissemination

Feedback was collected for this educational project utilizing a pool of thirteen students from Clarke Schools for Hearing and Speech, Pennsylvania. Parents and teachers were provided materials to utilize at home in support of language based mathematics standards, as outlined by the Pennsylvania State Standards.

The units, *Numbers and Operations*, *Algebraic Concepts*, *Measurement, Probability and Data*, and *Geometry*, were divided into binders. Each binder contained two units. *Numbers and Operations* was paired with *Algebraic Concepts*, while *Measurement, Probability and Data* were paired with *Geometry*. Families received the binder for a time period of one week. A feedback form was supplied, asking families to outline the materials that were enjoyable for their child,

suggestions for the materials, how the concepts will continue to be embedded in their daily routines, impressions of the aforementioned concepts in preschool and new feelings towards these concepts following implementation of unit materials. A rating scale was also used to ascertain information regarding ease of use, organization, materials supplied, benefit and perceived enjoyment.

Three sets of materials were created, for a total of six binders, to be disseminated amongst the thirteen families. Binders were sent home, one at a time, for a one week time period. Following their return, lessons and accompanying materials were assessed, and resupplied, as necessary. Binders were then redistributed to new families. Over the six week data collection period, families received at least one binder. Six families received both binders, completing materials for all four units outlined.

Qualitative Data

Project participants provided narrative data, outlining the successes and struggles of the home-based materials provided. Content analysis was conducted on the narrative feedback from parents to identify themes and patterns within open ended questions.

Feedback

Feedback forms were obtained from fifteen families. Seven feedback forms were obtained from the *Numbers and Operations* and *Algebraic Concepts* binder and eight forms from the *Geometry* and *Measurement, Probability and Data* binder. Families were asked to provide narrative information regarding the activities they tried with their child, as well as any favorite activities. Additional information obtained included suggestions for revisions to activities, ways

to continue incorporating concepts and personal feelings towards the mathematic ideas included in the binders.

Numbers and Operations
Algebraic Thinking

What was your child's favorite activity?	**Number of Responses**	**Total Percentage**
Ten Fat Turkeys, Tony Johnston	3	14.3%
Clothespin Number Match	3	14.3%
Roll and Build Block Towers	2	9.5 %
Playing Card Math	1	4.8%
Quack and Count, Keith Baker	2	9.5%
Placemat Patterning	5	23.8%
Ladybug Addition	4	19%
Subtraction Bowling	1	4.8%

	Yes	**Somewhat**	**No**
Were the directions concise and easy to follow?	100%		
Were the materials well organized?	100%		
Were the materials appropriate to support the lessons?	85.7%	14.3%	
Were the lessons easy to use with your child?	85.7%	14.3%	
Did your child gain educational benefit from the lessons?	85.7%	14.3%	
Did your child have fun with the activities?	85.7%	14.3%	

In what routines will you continue to incorporate "Numbers and Operations" and "Algebraic Thinking"?	**Number of Responses**	**Total Percentage**
Mealtime	5	50%
Around the house	1	10%
On the Go	2	20%
Work books	1	10%
Playtime	1	10%

Families were asked to identify their initial impressions of the concept titles, "Numbers and Operations" and "Algebraic Thinking." Narrative feedback suggested families were

surprised to see this terminology used in preschool. Comments indicated families gained confidence in their ability to act as their child's teacher in facilitating language-based mathematics concepts. Families also noted they are more conscious of opportunities for mathematics development. Additionally, awareness was raised regarding the connection between mathematics and literacy development.

Geometry
Measurement, Probability and Data

What was your child's favorite activity?	**Number of Responses**	**Total Percentage**
Mouse Shapes, Ellen Stoll Walsh	5	29.4%
Shape Scavenger Hunt	3	17.6%
Pattern Block Creations	2	11.8%
Balancing Act, Ellen Stoll Walsh	2	11.8%
Making Play Dough	1	5.9%
Non-Standard Measurement	3	17.6%
Sorting Beads	1	5.9%

	Yes	**Somewhat**	**No**
Were the directions concise and easy to follow?	100%		
Were the materials well organized?	100%		
Were the materials appropriate to support the lessons?	100%		
Were the lessons easy to use with your child?	87.5%	12.5%	
Did your child gain educational benefit from the lessons?	100%		
Did your child have fun with the activities?	100%		

In what routines will you continue to incorporate "Geometry" and "Measurement, Probability and Data"?	**Number of Responses**	**Total Percentage**
Mealtime	4	33.3%
Creative Arts	1	8.3%
On the Go	3	25%
Bath Time	1	8.3%
Playtime	2	16.7%
Reading	1	8.3%

Families were encouraged to provide feedback regarding suggestions to enhance the enclosed materials. One suggestion outlined the need to practice drawing shapes. It was also proposed that activities be developed to help children differentiate between similar shapes, such as a circle versus an oval. The use of varied building materials, such as blocks or Lincoln Logs was also recommended.

Families were asked to describe their initial impressions on the topics of "Geometry" and "Measurement, Probability and Data," as well as describe how the provided materials impacted their feelings. Of the eight feedback forms received, three indicated that the materials sparked ideas for ways to implement these math concepts at home. Four families indicated feelings of "surprise," "concern" and "overwhelm" by the titles in this unit. However, after engaging their child in these activities, feelings became more positive. Comments also indicated the importance of vocabulary development in comprehension of math concepts, specifically in regards to the terms *greatest* and *least*. Overall, families indicated that it is never too early to begin engaging their child in mathematics.

What I Learned

As a student, math was not my favorite subject. However, in investigating mathematics foundations at the preschool level, I found the concepts to be fascinating. Before students are able to add and subtract or collect data, a great deal of foundational language needs to be present. In developing these materials, I enjoyed identifying the connections between mathematics and language. To complete arithmetic, an immense amount of vocabulary must be comprehended. By providing opportunities to investigate these concepts at a young age, I hope that children develop an appreciation of math.

This project also identified the cross-curricular components of mathematics. Books serve as a "hook" to introduce new concepts, review information and explore the world around us. By delving into math, through literature, we investigate the role of language in computation. In addition to reading, math has cross-curricular ties with science. For students to collect data on science projects, they must measure, compare and contrast. Mathematic engagement even occurs during free play, as students construct using blocks. Through the development of project materials, I have a better recognition of the role of mathematics in all aspects of the day, including the classroom and the home.

What I Would Do Differently

Materials were distributed among children, ages four and five, with hearing loss. To gain more information on mathematic engagement, I would distribute materials to children with typical hearing as well. This would grant insight on parent perception of mathematics across a broader range of children. It would also provide feedback to allow for comparison of the populations.

Unit materials included mostly direct instruction activities. Although suggestions were provided for carryover activities at home, I believe there is more benefit in incorporating math concepts within daily routines. Given the opportunity to redesign unit materials, I would incorporate more activities within daily routines. To give a family an activity and subsequently ask for it to be returned following a one-week period does not truly provide full exploration of the topic. However, if I could have created activities embedded within routines at home, this would allow families to complete them on a daily basis, while incorporating targeted concepts.

Families received materials for one week, over the six week dissemination period. However, unit materials contained eight activities for families to try. Although the weekend was included in the allotted time for families to complete materials, more time would be beneficial to truly allow families the opportunity to explore these concepts. As I continue to investigate these math concepts, I would like to allow families more opportunities to try activities at home, so that they can fully expand their understanding of them.

A common comment from the *Numbers and Operations* unit was that children were competent in identifying numbers from one to ten. Unit materials and the accompanying story looked solely to foster number development from one to ten, as outlined by the Pennsylvania State Standards. To expand on this concept, incorporating numbers from eleven to twenty would also benefit families. This could have been accomplished by generating a second number wheel and clothes pins or encouraging families to create their own experience book, in which they identify items around the house in quantities of eleven to twenty. By expanding the number sequence, students are given the opportunity to further develop their concept of counting and recognizing numerals.

Activities in preschool are hands on and require durable construction. Contact paper was used to laminate some materials; however, it did not prove sturdy. Families reported materials peeling apart and subsequently impacted their ability to utilize them. In reproducing these materials, I would seek to use more durable lamination.

Impact as a Teacher

As a teacher of the deaf, I target language development in the children with whom I interact. However, in developing this project, I realize a great deal of language development is

involved in mathematics. Although computation is based in comprehension of numeracy, students must be able to recognize numbers and symbols in print. To expand this concept, students are expected to complete word problems, in which vocabulary must be decoded for successful computation. Further compounding computation is the word order delineated within the word problem. Comprehension and execution of syntax greatly impacts the ability to successfully complete a word problem.

In working with students, I hope to impose the importance of early comprehension of math concepts through meaningful experiences. My own, personal experience with math involved a great deal of drill and practice, used to gain comprehension. However, I hope to create activities that purposefully incorporate math within daily routines so that students have positive associations with math. Similarly, by creating awareness of mathematic concepts for parents, I hope that these concepts can better be incorporated within the home environment. Children spend a limited amount of time in school or with special instructors. Parents are in a unique role to serve as a facilitator of language and learning outside the parameters of the school environment. As a teacher, I can help in recognizing the opportunities to incorporate math at home and support parent development in regards to carryover of skills.

References

(2014, March 25). *Race to the top fund*. Retrieved from http://www2.ed.gov/programs/racetothetop/index.html.

Frye, D., Baroody, A. J., Burchinal, M., Carver, S. M., Jordan, N. C., & McDowell, J. (2013). *Teaching math to young children: A practice guide* (NCEE 2014-4005). Washington, DC: National Center for Education Evaluation and Regional Assistance (NCEE), Institute of Education Sciences, U.S. Department of Education. Retrieved from the NCEE website: http://whatworks.ed.gov

Hachey, A. C. (2013). The early childhood mathematics education revolution. *Early Education & Development*, *24*(4), 419-430.

Howell, S. C., & Kemp, C. R. (2010). Assessing preschool number sense: Skills demonstrated by children prior to school entry. *Educational Psychology*,*30*(4), 411-429.

Kritzer, K. L., & Pagliaro, C. M. (2013). An intervention for early mathematical success: outcomes from the hybrid version of the building math readiness parents as partners (MRPP) project. *Journal of deaf studies and deaf education*, *18*(1), 30-46.

National Association for the Education of Young Children and National Council of Teachers of Mathematics. (2002). *Early childhood mathematics: Promoting good beginnings.* Retrieved from http://www.naeyc.org/files/naeyc/file/positions/psmath.pdf.

National Association for the Education of Young Children. (2012). *The common core state standards: Caution and opportunity for early childhood education.* Retrieved from http://www.naeyc.org/files/naeyc/11_CommonCore1_2A_rv2.pdf

National Council of Teachers of Mathematics. (n.d.) *Prekindergarten focal points*. Retrieved from http://www.nctm.org/resources/content.aspx?id=7352

National Governors Association Center for Best Practices & Council of Chief State School Officers. (2010). *Common Core State Standards*. Retrieved from http://www.corestandards.org/

Nunes, T., & Moreno, C. (2002). An intervention program for promoting deaf pupils' achievement in mathematics. *Journal of Deaf Studies and Deaf Education*, *7*(2), 120-133.

Office of Child Development and Early Learning: Pennsylvania Department of Education and Department of Public Welfare. (2009). *Pennsylvania learning standards for early childhood*. Retrieved from http://www.pakeys.org/uploadedContent/Docs/PD/Standards/Pre-Kindergarten%202010.pdf

Pagliaro, C. M., & Kritzer, K.L. (2013). The math gap: A description of the mathematics performance of preschool-aged deaf/hard-of-hearing children. *Journal of Deaf Studies and Deaf Education, 18 (2),* 139-160. 10.1093/deafed/ens070

Pennsylvania Department of Education. (2014). *Standards aligned system*. Retrieved from www.pdesas.org/Standard/Views#104|14123|0|0

Purpura, D. J., Hume, L. E., Sims, D. M., & Lonigan, C. J. (2011). Early literacy and early numeracy: The value of including early literacy skills in the prediction of numeracy development. *Journal of Experimental Child Psychology*, *110*(4), 647-658.

Skwarchuk, S. (2009). How do parents support preschoolers' numeracy learning experiences at home?. *Early Childhood Education Journal,37*, 189-197. 10.1007/s10643-009-0340-1

Utah State Office of Education. (2013). Utah's early childhood core standards. Retrieved from http://www.uen.org/core/prek/downloads/EarlyChildhoodStandards2012.pdf

Zarfaty, Y., Nunes, T., & Bryant, P. (2004). The performance of young deaf children in spatial and temporal number tasks. *Journal of Deaf Studies and Deaf Education, 9 (3)*, 315-326. 10.1093/deafed/enh034