The Development and Evaluation of the Wesleyan Preschool-Math Curriculum

by

Mary Toomey
Class of 2017

A thesis (or essay) submitted to the faculty of Wesleyan University in partial fulfillment of the requirements for the Degree of Bachelor of Arts with Departmental Honors in Psychology

Middletown, Connecticut April, 2017
Acknowledgments

I wish to thank Professor Anna Shusterman whose energy and drive make the impossible possible. I am so grateful for the constant encouragement and invaluable insight that she brings to everyone around her. I will forever be inspired and motivated by her ability to remain calm and thrive in stressful situations. I have learned and experienced so much because of the opportunities she has given me.

I am indebted to our incredible lab manager, Madeleine Barclay. Maddy is an integral part of the Blue Lab. In addition to running the lab so effectively, she always brings such happy and positive energy. I am so appreciative of every member of the Blue Lab, Megan Dolan, Gaby Montinola, Emily Kaplan-Levenson, Jordan Ellman, Sara Dean, Joy Adedokun, Natalie May, Sifana Sohail, and Harry Jiang. I was so fortunate to have their help building toys in the machine shop, testing them in preschool, as well as constant support.

I would also like to thank Thomas Castelli, from Scientific Support Services, whose help was vital. I am incredibly grateful for his continual humor and kindness.

I want to acknowledge all the input and work Megan Dolan and Sonia Max, as well as all other students or research assistants, contributed to the curriculum. They worked with me all summer, and many of their ideas have improved the games vastly.

I also thank Caroline Messenger and the 22 Naugatuck preschool teachers, who contributed invaluable advice and which I appreciate immensely.

Finally, I would like to mention my friend, Leyla Wade, and my mother, Joan Toomey, who listened to me talk about the curriculum and offered critical support throughout.
Abstract

Converting research into practice is a difficult task that plagues many fields, including physical and mental health practices, policy, and education. The Wesleyan Preschool Math Curriculum was created to help bring research into preschools, specifically to help teachers apply numeracy research in their classrooms. Preschool math skills are predictive of better outcomes in math, literature, and general academic success, so it is vital that all research is utilized effectively in school. Twelve games were designed based on current numeracy and education research. Throughout the design of the games, the teacher feedback has been greatly valued. Additionally, we hoped the games would fill gaps in preschool math education that other curricula do not meet. Finally, the games are being tested and evaluated by 22 teachers from four schools in the Naugatuck area. The evaluation consists of four online surveys and focus groups, two of which have been completed. Thus far, we have received encouraging qualitative feedback, as well as high ratings (current average overall game score = 8.9/10). Teachers have also offered valuable suggestions for game alterations. As production continues, games will be altered according to the teachers’ suggestions and criticisms.
# Table of Contents

Acknowledgements.................................................................................................................. 2

Abstract ...................................................................................................................................... 3

Introduction ................................................................................................................................. 5

The Wesleyan Preschool-Math Curriculum Niche ................................................................. 15

Design and Production of Curriculum .................................................................................. 22

Teacher Feedback Study ......................................................................................................... 31

Discussion ................................................................................................................................. 42

References ................................................................................................................................. 47

Appendix A ............................................................................................................................... 52

Appendix B ............................................................................................................................... 54

Appendix C ............................................................................................................................... 55
Introduction

Connecting Research to Practice; A Difficult but Necessary Process

Through research, one can discover answers to innumerable questions, but truly applying those answers presents another challenge. Without the ability to translate findings from research into practice, the information gathered cannot make an impact. These gaps between what is known and what is applied are common in all fields. Research regarding disease and illness prevention programs are “rarely implemented in applied settings” (Glasgow, Lichtenstein, & Marcus, 2003). For example, extensive funds are put into clinical health research, very little is known about the actual cost of integrating it with practice (Bero et al., 1998) and clinical practice guidelines are rarely effective (Davis & Taylor-Vaisey, 1997).

Furthermore, the effect and role of the professional who would implement the research is understudied and often unaccounted for. The National Health Institution has suggested that implementation does not need to be considered a research a topic in its own regard (Biglan, Mrazek, Carnine, & Flay, 2003). This lack of focus on such a critical process is one of the biggest obstacles facing the goal of putting research into action. Some of the current issues encountered in implementation are due to “limited time and resources of practitioners, insufficient training, lack of feedback and incentives for use of evidence based practices, and inadequate infrastructure and systems organization to support translation” (Glasgow et al., 2003). Lack of funding for training and compensation often results in improper implementation of the research or nothing at all.
Preschool education is no exception. Though monumental strides have been made in the understandings of young children’s cognitive development, implementation of the research is not usually observed in the classroom. It is not difficult to see why, as funding and time for training, resources, and support are large obstacles that schools and researchers often face. Biglan et al argues that if more empirical findings are applied to child rearing, bringing research into practice will become more present in all areas (Biglan et al., 2003). Though the problem of translating research into practice effects all fields, it may be wise to prioritize bringing education research into schools.

The Significance of Preschool Math

Preschool math is a clear instance of the lack of and need for translation of research into practice. Unfortunately, much of this research is not used in school, even though it has been shown that children’s preschool counting abilities can predict many outcomes for children, even after graduating high school.

Preschooler’s ability to count, compare, and understand the meaning of numbers are all associated with later academic success. Preschoolers who use approximation to differentiate between two quantities of objects often go on to possess higher than average math skills (Aunio & Niemivirta, 2010; Libertus, Feigenson, & Halberda, 2011). Not only does preschool math competency increase the likelihood of success later in their math education, it also predicts their reading skills, even into high school (Douglas Clements & Sarama, 2013; Shager et al., 2013). Shockingly, preschool math can predict reading achievement even more accurately
than preschool reading skills can (Douglas Clements & Sarama, 2013). Preschool reading skills, however, do not predict later math ability (Lerkkanen, Rasku-Puttonen, Aunola, & Nurmi, 2005). Furthermore, preschool education in general has shown to improve life outcomes for children, such as socioeconomic status (Duncan, Ludwig, & Magnuson, 2007).

Entering kindergarten with a strong math foundation is vital for children to have a continually successful mathematical and academic experience. Therefore, preschool children must have access to “a high quality, accessible, and challenging mathematics education” (DH Clements, Copple, & Hyson, 2002).

**Numeracy Development**

Numeracy, the ability to understand and work with numbers, is embedded into vertebrate instinct, and its development in humans during the preschool years lays down vital groundwork. Human numeracy development begins with two basic systems used for representing and understanding number, shared by non-human primates and even fish (Carey, 2004b). Further in development, three counting principles have been established to unpack the complex nature of meaningful counting (Gelman & Gallistel, 1986). A system of levels to represent a child’s current numerical knowledge has been developed to inform teachers empirically of each of their student’s unique abilities (Sarnecka & Carey, 2008).

Number knowledge is built upon two systems: the object file system and the approximate number system (Gelman & Gallistel, 1986). The approximate number system is used to understand quantities to an inexact degree, but still allows for
comparison of different amounts. If the discrepancy between the amounts is large enough, even six-month-old infants can discriminate between the quantities (Xu & Spelke, 2000). Six month olds can notice differences between quantities that differ by a ratio of 1:2, but 9 month olds only need a ratio of 2:3 (Xu & Spelke, 2000). This system, however, does not offer information about exact quantities in the way that integers do.

Second, infants have an object file system to represent small number (i.e. 1, 2, and 3). When using the object file system, babies represent each object with one symbol, “creating a mental model of ongoing events”, letting them keep track of small, exact amounts (Carey, 2004b). Infants can use this system to account for up to 3 objects. Researchers Lisa Feigenson and Susan Carey demonstrated that infants will notice the exact difference between quantities 1-3 with their manual search task (Feigenson & Carey, 2005). Infants were shown 1, 2, 3 or 4 balls, which were then placed into a covered box, where the baby could reach in and retrieve the number of balls. Indicated by search time, infants consistently noticed discrepancies between quantities of 1, 2, or 3 balls. This system, however, was no longer precisely accurate when used for quantities of 4 or more (Feigenson & Carey, 2005).

Language also offers children clues as they figure out their counting and the meaning behind the numbers. If a baby’s first language does not distinguish between singular and plural begin to fully comprehend the meaning of 1 months after babies whose first language does use singular and plural (Carey, 2004b). Using their object-file system for exact numbers, their approximate number system for larger amounts, and their understanding of number resulting from quantifiers in language, even small
infants are already on their way to numeracy. In fact, Susan Carey suggests that children can use “bootstrapping” to apply these concepts to counting. Children learn the correct order of numbers, the count list, before they understand what each number word represents. Children use their symbolic and linguistic understandings of quantity and begin to attach them slowly to this list. The connections children are able to map helps them to arrive at the concept that the number that follows number, n, is n +1, or that each following number is one more than the previous number in their count list (Carey, 2004b).

Researchers Gelman and Gallistel created a three principle system that outlines the processes that make up that explain why counting is representative and meaningful (Gelman & Gallistel, 1986). These three principles are the one-to-one principle, the stable order principle, and the cardinal principle. The stable order principle requires that the order of numbers in the count list remains consistent and correct. For example, a child who counts “1, 2, 5, 3” has not achieved understanding of this principle. The one-to-one principle indicates that “one and only one numeral is assigned to each of a set” (Gelman & Gallistel, 1986). When learning to count, adults often help children apply this principle by pointing to each individual object as the child counts. The cardinality principle describes the purpose of counting. The principle the last number counted for a set of objects is the number that represents how many objects are in that group (Gelman & Gallistel, 1986). Before understanding cardinality, a child may be able to accurately count 10 of their toys, but when asked how many toys all together, they answer incorrectly. This error is due to the fact that this child does not yet understand that when they count a set of objects, they are
informing themselves of the total quantity of the set. In other words, they don’t yet understand the purpose of counting.

As children continue to grow and learn, they begin to understand what each number word represents and slowly fulfill each of the three counting principles. The development of numeracy can be described in three main stages called knower levels: pre-knower, subset knower, and Cardinal Principle (CP) knower. Before this process begins, a child is considered a pre-knower and does not relate specific quantities with any of the number words (Sarnecka & Carey, 2008). Next, a child, usually 2.5 to 3 years old, is a subset-knower when they can apply this information to some number words, but cannot generalize it to their entire count list. For example, a child is a two-knower if, when asked for two objects, will give two objects and never gives two objects when asked for any other number. Finally, a child becomes a CP-knower. At this point, a child understands that counting is a tool used to determine the exact quantity of a set, and that the last word stated when counting represents the size of that set (Sarnecka & Carey, 2008).

**Numeracy Research Often Absent from Preschool Education**

Unfortunately, research findings such as knower-levels and counting principles are rarely utilized in preschool – a particularly perceptible disconnection between research and practice. Firstly, though the importance of preschool math is well established, it is often not prioritized in preschool classrooms. During an observation of preschool teachers, researchers saw that very little time was spent on math in the classroom – even when considering spontaneous discussion, songs
mentioning numbers, and other informal methods (Graham, Nash, & Paul, 1997). With the knowledge that simply speaking to children about math and number related concepts can boost preschooler’s math understanding, it is imperative that time spent teaching math increases (Klibanoff, Levine, Huttenlocher, Vasilyeva, & Hedges, 2006).

Secondly, the research based curricula provided for preschool teachers is often not put into use. A study conducted in 2014 found that preschool teachers rarely use a math curriculum, and when they do, they pick and choose pieces of the full curriculum (Lo, 2014). The Kindergarten Common Core Standards for Mathematical Practices require that kindergartners fully understand cardinality, yet the time that is spent on math is often filled with reciting the count list and recognizing the Arabic numerals.

**The Wesleyan Preschool-Math Project**

The Wesleyan Preschool-Math Curriculum hopes to bring what is known from the research into the classroom by incorporating three unique features. First, the curriculum includes a game named Give-A-Number (Schaeffer, Eggleston, & Scott, 1974), a tool used for assessment in research (Carey, 2004a), which teachers can use to identify each students’ level of numeracy understanding (Wynn, 1990). Second, each game includes elements of each of the three principles of counting. Third, the curriculum has been developed keeping teacher needs in mind.

Give-A-Number, a game developed and used in previous studies (Carey, 2004a), is easy to use, intriguing and entertaining for children, and offers teachers
insight into how much a child truly knows about numbers. In Give-A-Number, a teacher asks a child for a certain number of fish, starting with 1, ascending with each correct answer. Children first give an amount of fish, are asked to count to check, and then correct if they notice any errors. This game allows teachers to center in on what their student’s knower-level is. Once a teacher has ascertained the students’ knower-levels, they can tailor games to each individual child and keep track of progress made over the course of the year.

The curriculum consists of 12 games, one of which is Give-A-Number. The other 11, designed over the course of years of Wesleyan students and research assistants, have been created with the purpose of teaching the three counting principles: one to one, stable order, and the cardinal principle. In the final developmental stages of the games, five more skill goals have been added: ability to compare quantities, approximation, recognition and application of Arabic numerals, understanding of different representations of number, and understanding of the foundations. Each game includes the three main principles and different variations of the additional skills (Purpura & Lonigan, 2013; Whyte & Bull, 2008).

Finally, the games were created with the purpose of being suitable to teacher needs and practical for the classroom. For instance, the curriculum does not direct teachers to follow an exact order of the games or amount of time to play each game. The games are designed to be fun, so that students and teachers are naturally drawn to them, and flexible, so that they can be altered to fit a child’s growing math knowledge or played with by students of different math skill levels. Throughout development, the
games were brought to preschools where teacher and student reactions were noted and used to inspire corrections.

**Development of the Preschool Math Curriculum**

The original goal of the curriculum was to bridge between research and practice in preschool math education. The curriculum began in Professor Anna Shusterman’s Psychology 206 class, a research methods class and continually advanced through iterations of this class. The curriculum also became the subject of research assistants’ summer and term-time projects. The games were used in Kindergarten Kickstart, a Middletown, CT, preschool program focused on readying children for kindergarten, by professional and undergraduate teachers. Third, the games were brought weekly to a preschool in Middlefield, CT, to be refined before the first round of production on a larger scale. Finally, the knowledge gained from years of trial and error as well as invaluable experience with preschool students and advice from teachers was culminated into a finalized set of 12 games.

The games originate from Psychology 206, Research Methods in Cognitive Development and Education. In addition to focusing on study design, ethics, and analysis, the class emphasized numeracy, teachers’ needs, and the translation of research to implementation. The class required that students serve as “Wesleyan Math Ambassadors”, bringing games to preschools. Finally, students completed a final project including a description of one of the games, improvements made to it, and experiences implementing it at preschool.
During the Wesleyan Summer Research Experience, research assistants worked with Professor Shusterman to focus on perfecting the games. Each week, research assistants brought new and improved games to preschool. In order to gather more feedback, a math playgroup was organized, where a group of children could try out the games in a smaller setting. The consistent focus, time, and funding for the games resulted in great leaps in the design and materials of the games. Some of the games began to be produced in the Wesleyan woodshop with the help of Thomas Castelli, a member of the scientific support services. Along with helping us design our games, Tom also taught every current research assistant how to operate machines to help produce the games. Our collaboration with him resulted in the realization of the games existing as well-crafted wooden toys. Finally, the games appeared to be near completion, but I brought them each week to preschool to make any final corrections. I went to school with members of the Wesleyan Cognitive Development Blue Lab for additional perspectives. Some research assistants had previously worked on the games, and some knew very little about them, thus they were able to provide a good range of feedback with fresh perspectives. As the games were finalized, the Wesleyan wood shop and print shop supported the production of 20 sets of the curriculum.

**Teacher Feedback Study**

To evaluate the games, teachers were recruited to participate in a feedback study. To date, the finalized games have been evaluated over the course of 3 weeks by 21 teachers from four different schools in the Naugatuck school district. The
teachers filled out an initial survey regarding the math they incorporated into their classroom. Each week I distributed the three games and explained them to the teachers. Throughout the week teachers filled out a survey about the games. The following week, I held a focus group with the teachers who provided an abundance of invaluable feedback.

Overall, the feedback given in the focus group sessions and surveys was very positive. Games scored an average of 9/10 on questions such as “How easy was it to use this game in your classroom” and “How much do you think this game would improve your students’ math skills”. The teachers provided me with pictures of students enjoying the games as well as data they collected about their students’ knower-levels after playing Give-A-Number. In addition to positive feedback, the teachers provided constructive feedback that will be incorporated as the games are produced.

Considering the effect preschool math ability has on future academic and life success and the plethora of research regarding numeracy development, it is imperative that what is known about numeracy be applied in the classroom. This curriculum, which incorporated teacher input throughout the development process, will hopefully make a step towards connecting research and implementation.
The Wesleyan Preschool-Math Curriculum Niche

Preschool math curricula do exist, but the Wesleyan Preschool Math Curriculum was designed to improve upon the flaws and magnify the benefits of current options. We spoke to teachers, took advantage of hands-on undergraduate input, employed an iterative approach to design, and piloted the games in a set of demographically-diverse preschools, with varying structures and philosophies. We focused on enhancing the feasibility of implementation, the creation of materials of greater quality and design, and producing a curriculum that allows for the possibility for a child to play and learn independently or in a group setting. These methods allowed us to develop games and activities that fill the niche of flexible, adaptable, and effective preschool math curricula that no other existing curricula currently occupies.

The Preschool Math Landscape

Studying examples of math curricula currently used in preschools allowed us to assess their strengths and weaknesses and create activities that could accomplish what existing materials could not.
Table 1

*Examples of Research-Based Curriculum*

<table>
<thead>
<tr>
<th>Curriculum</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Building Blocks</em></td>
<td>Uses a structured lesson plan with different themes and corresponding math activities for each week that aim to provide preschoolers with foundational math skills (Clements &amp; Sarama, 2007).</td>
</tr>
<tr>
<td><em>Big Math for Little Kids</em></td>
<td>Created specifically for preschoolers and kindergartners, this National Science Foundation funded curriculum uses a series of activities to foster continuous numeracy development (Carole Greenes, 2004).</td>
</tr>
<tr>
<td><em>DLM Early Childhood Express Math</em></td>
<td>Comprises a small group activities, at-home exercises, computer software, and manipulatives, found to have positive effects on preschoolers’ math skill level (Clearinghouse, 2013).</td>
</tr>
<tr>
<td><em>Number World</em></td>
<td>Developed on state standards, this curriculum begins at PreK and goes through 8&lt;sup&gt;th&lt;/sup&gt; grade. The curriculum is paired with Building Blocks, a complementary set of computer activities (McGraw-Hill, 2017).</td>
</tr>
</tbody>
</table>
Building Blocks (Clements & Sarama, 2007) and Big Math for Little Kids (Lewis Presser, Clements, Ginsburg, & Ertle, 2015) are evidence based and have been shown to have positive effects on children’s numeracy (National Center on Quality Teaching and Learning, 2015), whereas Number Worlds (McGraw-Hill, 2017) has not shown strong effects on child outcome (National Center on Quality Teaching and Learning, 2015), and DLM Early Childhood Express Math was significantly less effective than Building Blocks (Sarama & Clements, 2004). Building Blocks and Big Math for Little Kids are two examples of curricula used widely in preschools that receive funding from the National Science Foundation. These curricula show that several approaches and research models can work well to create an affective set of lessons and materials, which can be implemented in the construction of future curricula.

Building Blocks focuses on “emphasizing teacher’s social construction of knowledge and beliefs” and the theoretical approach of “constructivism” (Sarama et al, 1998). The curriculum’s goals are for students to gain independence and develop problem solving skills. Cohen and Ball demonstrated that teachers have independent knowledge and beliefs that affect their implementation of curricula (Cohen & Ball, 1990), so Sarama et al sought to understand teacher predispositions. Sarama et al accounted for teacher expectations in the explanation of their activities. Understanding and working with teachers’ perspectives allows for the curricula to be more realistically utilized, and we made a point to utilize this approach when developing the Wesleyan Preschool-Math Curriculum.
Big Math for Little Kids developed by Presser and colleagues is also currently utilized in preschools. It was developed using a set of principles, one of which included a focus on the needs of low-income children (Presser et al., 2015). Considering different types of groups of children and how each may learn in varying ways is an important part of developing an adaptable curriculum. Their goal was to develop a curriculum that gave low-income children special attention in terms of expressing their mathematical thinking (Lewis Presser et al., 2015). This focus resulted in these low-income children learning more than in the control (Lewis Presser et al., 2015).

Teachers’ Use of Existing Curricula

One of the most important goals for the Wesleyan Preschool-Math Project is that teachers will find it realistic and easy to implement in their classroom. Research focused on teachers’ opinions about current curricula determined what teachers weren’t getting from preschool math curricula (Lo, 2014). Lo reported that most teachers don’t follow criteria in the instructed order or time frame, as these criteria are often unrealistic in a preschool setting. Generally, many teachers use a “mix and match approach” (Lo, 2014) that uses the materials provided by the curricula, but not in the suggested order or manner, as following a strict daily lesson plan is unrealistic when working with preschool age children. Instead, picking any applicable or favored activity allows for the flexibility that is needed for an unpredictable environment. Furthermore, Lo found that many teachers prioritized literacy over
numeracy (Lo, 2014). This preference may occur for several reasons, but the rigidity of the available math curricula is a possible contributor.

The Gaps Addressed by the Wesleyan Preschool-Math Curriculum

The Wesleyan Preschool-Math Curriculum has been developed to be a realistically implementable set of games, designed with thorough teacher evaluations and feedback to be adaptable to an unpredictable preschool setting. The curriculum is designed to be feasibly utilized in the classroom, as it is comprised of a set of adaptable games that are not set to a lesson plan, so they can be used in any order. Alterations can be made to the games to make them easier or harder (i.e. differentiate up or down) so that the games can be played at any point in the school year with children of any math ability. For instance, Math Garage, a game where preschoolers park cars with Arabic numerals onto parking spaces with the corresponding number of dots, can be used for children beginning to learn to count, as well as with more advanced children. To make it easier, the pieces can be flipped to a blank side so that students can focus on smaller numbers. If children need more of a challenge, the parking spaces can be rearranged, and classmates can race to fill their parking lot correctly before the other.

Sarama et al kept teacher perspectives in mind while training teachers to utilize the curriculum (Sarama, Clements, & Henry, 1998). The Wesleyan Preschool-Math Curriculum has been developed from the start with the help of teacher input. Through each stage of development, the games have been regularly brought into preschool settings, where teachers often offered suggestions on how to make
improvements. Currently, the curriculum is in the process of its Teacher Feedback Study, so that the game can be evaluated by teachers before tested for efficacy. This study uses surveys and focus groups to gather teacher input.

**Wesleyan Preschool-Math Curriculum Limitations**

The Wesleyan Preschool-Math Curriculum still has work to accomplish, however. The curriculum requires testing on efficacy, added features and more comprehensive instructional materials. Most importantly, a study must be conducted to determine the efficacy of the curriculum. If the curriculum’s efficacy is confirmed by the study, other aspects, such as an associated set of computer activities, should be developed to build upon the 12 core games. Though the Wesleyan Preschool-Math Curriculum games have corresponding instruction sheets, a more organized form of curriculum training is needed. Creating instructional videos for each game would be easily distributed and could lead to more effective implementation.
Design and Production of Curriculum

Game Development Methods

The development of the games occurred in three different forms: a project for a psychology research methods class, Research Methods in Cognitive Development and Education, summer research projects during the Wesleyan Summer Research Fellowship, and as an observation and discussion based in-lab evaluation. Each phase of development took a variety of input into account, specifically highlighting teacher feedback.

The games originated from Research Methods in Cognitive Development and Education, a class that centered on numeracy development and service learning taught by Professor Anna Shusterman. The topics of research methods, ethics, and scientific writing were applied during the final project, which required students to create preschool math games, implement them in Middletown preschools, and report on their successes and shortcomings. The class has been taught six times, and each year the final projects improved upon the games created in previous years, in addition to generating new games. This course-based development allowed for a diverse range of input from around 90 Wesleyan undergraduate students. The project was set in motion as the class compiled a list of educational preschool game “desiderata” or desired components. Each year, a different group of Wesleyan undergraduates composed a new “desiderata” list, but many qualities were mentioned each year, such as adaptability, intriguing and kid-friendly materials, and capacity to be played with teacher instruction, as well as independently. Each week, students implemented, tested, and altered games as “Wesleyan Math Ambassadors” at preschools such as
Snow School, Headstart, Neighborhood Preschool, and the YMCA Preschool. Students recorded their observations as well as teacher reactions and suggestions in journals. Over the six semesters this class was taught, students contributed to the design of many games, eleven of which have been included in the Wesleyan Preschool Math Curriculum.

The development of the games continued during the Wesleyan Summer Research Fellowship of 2013 and 2015. In 2013, research assistants, Andrew Ribner, Julia Vermeulen, Simoneil Sarbh, and Angela Lo accelerated the development of four games included in the curriculum: Monster Math, Pizza Math, Panda Palace, and Fishing for Numbers. Research assistants brought each game to preschool several times, improving upon it each day based on the issues they encountered. This process was repeated until they felt satisfied with the quality of each game, at which point the research assistants constructed instruction sheets for each game.

The Wesleyan Summer Research Fellowship of 2015 followed a similar plan carried out by Megan Dolan, Sonia Max, and Mary Toomey. Final versions of seven games, Math Bus, Fish Friends, Math Garage, Elephants at the Circus, Trail Mix, Beading Towers, and Sock Puppet Shopping Trip, were completed, along with their corresponding instruction sheets. A list of critical preschool math skills was composed to outline objective goals for each game. These skills include the three cardinal principles (Gelman & Gallistel, 1986), comparison, approximation, recognition and application of Arabic numerals, understanding of different representations of number and quantity, and understanding of the foundations of addition. Over the course of the summer, we began to produce game prototypes in the
machine shop, creating a more professional and functional version of each game. In addition to playing the games at local preschools, a math playgroup for preschoolers was organized so that the games could be observed in a more focused, individualized setting. The games were also included at Kindergarten Kickstart, a summer preschool program that prepares children for kindergarten. We incorporated our own experiences as well as professional and undergraduate teacher feedback to refine the games.

Finally, the 11 refined games were fine-tuned by a group of Cognitive Development Lab research assistants, Gaby Montinola, Emily Kaplan-Levenson, and Megan Dolan who had varying experience with the games. Each week, two available research assistants and I brought a different game to Middlefield Children’s Center. We created a collaborative document to organize our interpretations of each implementation. After each game was observed, the research assistants and I met to discuss the final alterations needed before the Teacher Feedback Study. Examples of these changes include making the games safer for children by rounding out sharp edges of some of the materials and adding another dimension to Beading Towers by using colored balls to be used for comparison and patterning.

Production

After the 11 games were generated by students of Research Methods in Cognitive Development and Educated, improved during the Wesleyan Summer Research Fellowship, and refined through observation at Middlefield Children’s Center, the finalized versions were set for production. Twenty sets of the 11 games
and Give-A-Number, the curriculum assessment tool, are on track to be completed for the first round of production. Four sets of the curriculum were prioritized to be included in the Teacher Feedback Study. Thus far, four original games, Fishing for Numbers, Math Bus, Beading Towers, and Math Garage, have been distributed and evaluated.

In order to ensure that the games were produced with sturdy, high quality materials, we collaborated with Thomas Castelli, a member of the Scientific Support Services of Wesleyan, and Jen Platt, manager of the Wesleyan Print Services. Both have contributed greatly in the process of translating the games from handmade crafts into reproducible, polished products. With the help of Thomas Castelli in the machine shop, we constructed board games, toy busses, and thousands of drilled and painted balls. Through the Wesleyan Print Shop, we created laminated, colorful versions of small items, such as board game pieces.

Throughout the production of the games, the price of materials and labor has been tracked so an appropriate price could be estimated for a set of the curricula. The current cost per curricula is $279, including all purchased materials, prints, undergraduate and professional labor. The most expensive cost is labor (both student and professional labor), which is about $171.25 per set of games. The cost of student labor is only around $15 of the total labor cost. Professional labor is $156.25 per set. This amount of professional labor would likely decrease over time, as Thomas passes some of the responsibilities onto undergraduates. We can also expect a decrease in price per material if bought in bulk.
At the current cost estimate, however, the price per set would be $335, if sold at a 20% profit margin, but could be lowered if we produce the sets in larger quantities. Existing curricula contain different components (i.e. some include lesson plans, others include computer activities), which can complicate exact price comparison, but still describe the preschool curriculum market. For instance, the Building Blocks manipulatives package costs $395.52, which does not include the computer software license for a classroom of students that costs $226.23 per year or the teacher edition, which costs an additional $107.91 (Mc-Graw Hill, 2017). Other manipulative kits, such as HighScope and Childcraft, are priced at $299.99 and $323, respectively. The Wesleyan Preschool-Math Curriculum contains research-based games, teacher instructions, and an assessment tool, not simply manipulatives. Therefore, the price of $335 per set is a reasonable estimate.

**Design of Games**

The purpose of the design of each game was to ultimately improve children’s three counting principles: One-to-One Correspondence, Stable Order Principle, and Cardinal Principle (Gelman & Gallistel, 1986), in addition to other skills such as recognition of Arabic numerals and comparison. Each game was designed with the ability to adapt to each child’s current zone of proximal development – the point at which a task is too difficult to accomplish on their own, yet can be accomplished with the help of an adult (Vygotsky, 1987). Teachers can tailor the difficulty of each game to individual students, so the game can be used to scaffold their numeracy development.
Each game originated from numeracy research and improved after several rounds of implementation observation. The four games that have been evaluated by Naugatuck preschool teachers will be specifically described: Fishing for Numbers, Math Bus, Beading Towers, and Math Garage.

**Fishing for Numbers.**

*Goals.* Each game incorporates the three counting principles: One-to-One Correspondence, Stable Order Principle, and Cardinal Principle (Gelman & Gallistel, 1986). Fishing for numbers also incorporates recognition and application of Arabic numerals, understanding of different representation of number, and understanding of the foundations of addition.

*Description.* Children use magnetic fishing rods to collect fish based on number rolled with a dice or requested by a teacher. The set contains fish both with and without Arabic numerals. Teachers can ask for children to collect the right amount of fish or the fish with a numeral that corresponds to the number requested.

*Adaptations.* If a teacher is playing with CP-knowers (Carey, 2004), basic addition and subtraction can be incorporated by asking children to count the total number of fish, or “throw” fish back and recount the total.

**Math Bus.**

*Goals.* In addition to improving upon the three counting principles, Math Bus incorporates many opportunities to develop understanding of different representations of number, incorporated because children can use representations of numbers they
know best to scaffold their learning of other representations. Math Bus also includes features that emphasize Arabic numeral recognition.

Overview. Children act as bus driver or bus stop leader to coordinate the pick-up and drop-off of the puppets. One puppet is labelled with a one, two with the numeral 2, three with numeral 3, and four with numeral 4. Each bus stop has 1-4 dots, and a corresponding number of puppets get on or off at this stop (i.e. 3 puppets get on the bus at the 3rd stop). Once drop-off is completed, each stop will have the correct number of puppets, all labelled with the correct Arabic numeric (i.e. stop 1 will have one puppet labelled with “1”).

Adaptations. The stops can be put in numerical order to make it easier, as the order will demonstrate the proper stable-order count list. To make the game more difficult, the stops can be placed out of order, or the passengers can be required to be picked up or dropped off in reverse order, testing stable-order understanding. Teachers can ask students about total number of passengers after each stop, touching on the basics of addition and subtraction.

Beading Towers.

Goals. Beading Towers targets many math skills: the counting principles, understanding of different representations of number, understanding of the foundations of addition, comparison, and approximation. Preschoolers’ approximate number system has been found to correlate with early math achievement (Libertus, Feigenson, & Halberda, 2011). Therefore, this game was designed so that it could
enrich preschoolers’ approximation skills and connect them to their developing counting skills.

Overview. As this is one of the curriculum’s most flexible games, there are many ways to play. For instance, children can roll dice and add a corresponding number of balls to their stand until they reach the top. Alternatively, teachers can use the stands and balls to demonstrate that each number is one more than the previous number, illustrating the bootstrapping concept (Carey, 2004).

Adaptations. A way to simplify Beading Towers is to give children bowls filled with a small number of balls, and ask them to count as they add each ball, count the total, and compare with friends. This version emphasizes the One-to-One principle, the Cardinal Principle, and comparison. The game can become more difficult if children race to get to the top of the stand. Another difficult version of Beading Towers uses two dice. Students must add together the two values from the dice roll to find the total number of balls to add to the stand, offering a clear representation of addition.

Math Garage.

Goals. Math Garage focuses on recognition of Arabic numerals, understanding of different representations of number, and of course, the three counting principles. This game can be used to teach students about the relationship between quantity and Arabic numeral, or improve students’ numeracy understanding and fluency.
Overview. The game consists of a “parking lot” with ten parking spaces, each labelled with a 1-10 dots, and ten cars labelled with the Arabic numerals 1-10. Children are asked to park the cars in the correct parking space, which requires them to accurately count and determine the total number of dots on a space and recognize the corresponding Arabic numeral.

Adaptations. The parking spots are removable and can be turned to the blank side to focus on smaller numbers for less advanced students. The parking spots can also be rearranged for more advanced students. Students can also compete to see who can park their cars correctly first, which can keep children motivated for longer amounts of time.
Teacher Feedback Study

Introduction

As previously mentioned, many preschool teachers have found math curricula difficult to implement, and often pick and choose small portions of a curriculum, instead of implementing it as it was designed (Lo, 2014). Therefore, a feedback study incorporating teacher implementation was necessary to create a realistically functional curriculum. We conducted a qualitative and quantitative evaluation of teachers’ reactions to and opinions of the Wesleyan Preschool Math Curriculum. Our goals of the study were to a) learn about the teachers’ preexisting thoughts about preschool math, b) collect quantitative data in the form of ratings for different aspects of each game, and c) collect qualitative data about the games from open ended survey questions and weekly focus groups. The responses collected from the teachers will be used to correct or emphasize any features of the game as we continue to produce them.

Methods

Participants.

The participants of this study were 22 preschool teachers from the Naugatuck school district, recruited with the help of Caroline Messenger, the district’s curriculum director. The schools included were Salem Child Community Center, the Early Childhood Center at Central Avenue, and Andrew Avenue School. Two teachers from Hop Brook Elementary also participated, using the games in their kindergarten intervention groups. Each participant received $25 for completing the
online surveys and $25 for each focus group they attended as compensation for their time and input.

**Materials.**

The teachers receive the games that make up the Wesleyan Preschool Math Curriculum. Sets of games will be distributed by school, so teachers can share between classrooms. As additional compensation, each school can keep the full set of games free of charge.

**Procedure.**

This study is organized into 5 meetings: one introductory meeting and four focus group meetings, accompanied by an initial survey and 4 follow-up surveys. The first meeting consisted of a presentation of numeracy development by Professor Anna Shusterman and distribution of the first three games. The background information presented is a critical part of understanding the reasoning behind each of the games. For instance, the presentation described Give-A-Number as a tool for assessing students’ knower-levels. Additionally, the counting principles (Gelman & Gallistel, 1986) were explained, signifying to teachers the numeracy goals the curriculum focused on. Therefore, this numeracy-focused Professional Development may lead to a more successful implementation.

Following the presentation, teachers completed a survey (Appendix X) with the purpose of gathering information about teachers’ amount of formal training in math development and/or education as well as collecting baseline measures for amount of time spent on math throughout the week, use of curriculum, and other aspects of math in their classroom.
Three games, Give-A-Number, Fishing for Numbers, and Beading Towers, were introduced and explained to prepare teachers to bring them into their classrooms. Teachers were also given instruction sheets (Appendix X). Once every question had been answered, the sets of toys were distributed by school to be shared throughout the week.

Before each of the following three focus group sessions, an online survey was distributed and a focus group session was held to acquire both quantitative and qualitative feedback concerning each of the games. The survey consisted of three questions for each game rated on a scale from 1 to 10. First, teachers were asked to rate how easy each game was to incorporate into their classroom. Ability to realistically utilize the games was one of the main goals of the curriculum, so ease of implementation was a consequential factor. Second, teachers were asked to rate each of the games on level of student interest. When children enjoy a game, they will play longer, increasing time spent on math. Additionally, the games were designed with independent play involved, requiring that students are intrigued by and enjoy the games. Finally, teachers were asked to rate how much they thought the games could help students improve their math skills, as this is the ultimate goal of the curriculum. The online survey also contained an open-ended question, “Was there anything else you especially liked or disliked about the games?”.

In order to build on the open-ended responses, the participants then took part in a weekly focus group. The 30-minute sessions were recorded and notes were taken during. Though 9 questions were prepared for each session, the focus groups are discussion-based, and a considerable amount of feedback was shared when
responding to another teacher during the completed focus group sessions. The questions focused on general information (when/where/how were the games used), student responses, and the teachers’ professional opinions. Lastly, a portion of the focus groups was dedicated to discussing each game individually.

Due to conflicting schedules the number of games and duration of the testing period varied by meeting. The teachers have completed the first and second focus group sessions. Teachers had two weeks to use the first three toys before those games would be evaluated in the first focus group. The teachers had one week to implement two more games before the second focus group. The third focus group will take place after four weeks with three more games. Lastly, teachers will be given the remaining four games and a date for the last focus group will be set.

Results

The math background survey consisted of 5 questions rated on a Likert scale from 1-7, 2 yes/no questions, and 1 open-ended quantity question. In addition to these results, 5 out of 22 teachers indicated that they used a formal math curriculum, and 12 indicated that they used the math section of a math curriculum. The final numerical question was only answered by those that reported using either a formal math curriculum or math section of a comprehensive curriculum.

Table 1
Math Background Survey Responses
<table>
<thead>
<tr>
<th>Questions</th>
<th>Mean</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How much Formal Training in Math Education or Development?</td>
<td>4.19</td>
<td>5</td>
</tr>
<tr>
<td>2. How comfortable do you feel teaching math?</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>3. How well do you know your students’ math abilities?</td>
<td>4.61</td>
<td>3</td>
</tr>
<tr>
<td>4. How many hours a week do you spend on math in the classroom?</td>
<td>4.64</td>
<td>10.75</td>
</tr>
<tr>
<td>5. How interested are your students in math activities?</td>
<td>4.9</td>
<td>4</td>
</tr>
<tr>
<td>If applicable, how well do you think your curriculum addresses your students’ math needs?</td>
<td>3.69</td>
<td>3</td>
</tr>
</tbody>
</table>

Each question was rated on a Likert scale from 1-7. In addition to these results, 5 out of 22 teachers indicated that they used a formal math curriculum, and 12 indicated that they used the math section of a comprehensive curriculum. The final numerical question was only answered by those that reported using either a formal math curriculum or math section of a comprehensive curriculum.

The average responses were rarely high or low, but there were a few notable results. Hours per week had a large range (minimum was 15 minutes, maximum 11 hours). Additionally, the curricula currently used received relatively low ratings with regards to their ability to address students’ needs.
Table 2

Game Feedback Survey Responses

<table>
<thead>
<tr>
<th>Mean Response (out of 10)</th>
<th>Easy to use in classroom</th>
<th>Student interest</th>
<th>Potential to improve math skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>Give-A-Number</td>
<td>9.05</td>
<td>9.52</td>
<td>8.67</td>
</tr>
<tr>
<td>Fishing for Numbers</td>
<td>9.15</td>
<td>9.23</td>
<td>9.33</td>
</tr>
<tr>
<td>Beading Towers</td>
<td>8.89</td>
<td>9.33</td>
<td>9.11</td>
</tr>
<tr>
<td>Math Bus</td>
<td>8.86</td>
<td>9.14</td>
<td>7.93</td>
</tr>
<tr>
<td>Math Garage</td>
<td>9.45</td>
<td>9.73</td>
<td>9.27</td>
</tr>
</tbody>
</table>

The ratings for the first 5 games were all quite similar and positive – all means stayed above 7.0. All 22 teachers responded to the first three games, and 16 have currently responded to the last two games. Only Give-A-Number and Math Bus’ potential to improve math skills and Beading Tower and Math Bus’ ability to be easily used in the classroom received scores below 9 out of 10. Math Garage received consistently high ratings on all three measures.

Open Ended Survey Feedback.

Each survey asked, “Was there anything you especially liked or disliked about any of the games?”, giving teachers a chance to voice their opinions outside of the rating scales. This question was optional, but 15 teachers submitted responses for the first three games, and 12 for the second two.
Focus Group Feedback.

Two focus groups have been held to discuss the first five games. Each lasted around 30 minutes, and included personal experiences regarding where and how they played the game, their opinions and suggestions of the game, and their students’ responses. The focus groups were especially informative as many of the teachers compared their varying experiences with each game.

Discussion of the Teacher Feedback Study

Outcomes of Numeracy Presentation.

During the introductory meeting, Professor Anna Shusterman explained the basics of numeracy development behind the math games. We theorized that understanding the research behind the games would lead to better implementation. The presentation described the theoretical framework of numeracy, including approximate number sense (Libertus, Feigenson, & Halberda, 2011), the three counting principles of counting (Gelman & Gallistel, 1986), and the concept of knower-levels (Carey, 2004). The concept of knower-levels was later mentioned repeatedly throughout the focus groups. The teachers expressed the desire to be more aware of their students’ true level of understanding, and knower-levels can be used to describe this information. One central topic was the use of Give-A-Number as an assessment tool that could be used to determine a child’s knower-level. A few teachers later reported online and many indicated in the focus group that the presentation helped them determine their students’ math ability. One teacher reported, “It was interesting because a few (students) I thought understood to a certain number.
Using this game, I learned their knower-level was actually less, so the first math meeting was very helpful.” Other teachers brought in copies of notes they had taken regarding each student's’ knower level, determined using Give-A-Number.

**Math Background Survey Responses.**

The average responses were rarely at either the lowest or highest end of the scale, but two responses were especially striking. One, the time spent on math per week varied widely between teacher. Two teachers reported they spent an average of 15 minutes on math per week, while two other teachers reported that they spent 11 hours a week. Interestingly, one of the teachers who reported spending 15 minutes a week on math, rated other questions, such as “How interested are your students in math?”, higher than the average scores for other teachers.

Secondly, only about a quarter of the teachers reported using a formal math curriculum, such as Big Math for Little Kids. Around 57% of the teachers reported using the math portion of a comprehensive curriculum, such as The Creative Curriculum. Average scores regarding how well the curriculum suited the needs of their students, teachers who used both formal math curricula and comprehensive curricula an average of 3.7/7.

The results of this initial survey suggest that, within this group of teachers, the type and duration of math varies widely. Questions regarding student interest, amount of professional development in math education, and time spent on math varied widely between teachers. Additionally, the low rates of implementation, as well as the lower rating of how the curricula addressed preschoolers’ needs, which replicated previous
reports of preschool teachers’ dissatisfaction with the available curriculum (Lo, 2014).

**Online Game Survey Responses.**

The only scores lower than a 9/10 were given to Give-A-Number and Math Bus’ potential to improve math skills and Beading Tower and Math Bus’ ability to be easily used in the classroom. Give-A-Number, included mainly as an assessment tool, was not designed solely for educational purposes, so this slightly lower rating of potential to improve math skills is not unexpected. Give-A-Number is intended to be used intermittently throughout a school year to track improvement in each student’s understanding of number, unlike the other games which were designed to be played often. Beading Towers’ lesser rating in ease of implementation was likely due to the large quantities of balls that the game requires, which was explained in more detail in the open-ended question and at the focus group. Math Bus, which received the lowest scores overall, is one of the least adaptable games, as it focuses on lower knower-level children. Though this was a suspected problem with the game, we now have concrete quantitative responses indicating that the game needs to be altered to increase flexibility.

The online survey also contained an open-ended question, “Was there anything else you especially liked or disliked about the games?” The feedback, again, was quite positive. Out of 15 responses on the first survey and 12 on the second, the criticism was constructive and often involved easily remedied design flaws. For instance, the numbers written on the cars used in Math Garage faded over
the course of the week. The only game that received conceptual criticism was Math Bus. Two teachers reported issues adapting school bus to different knower-level students. A teacher also mentioned that it appears a teacher needed to be present to play the game. Otherwise, the adaptability of the games was mentioned 7 times. One teacher reports the games “made learning fun”.

**Focus Group Responses.**

Teachers reported that the games were used in many settings, including with large groups during circle time, smaller, more independent groups during center time, and one-on-one. Some teachers mentioned that children who are usually uninterested in math enjoyed the games very much. The group agreed that each of the games was quite easy to incorporate in class. One teacher, however, suggested this may be due to the novelty of the games, which is a notable limitation of the short-term trial period. Teachers offered valuable insight into the advantages and disadvantages of each individual game. For instance, several teachers stated their appreciation of Give-A-Number’s ability to assess students’ levels, mentioning that they were often surprised by what their students did and didn’t know. One teacher showed a chart she made with each student’s knower-level determined by Give-A-Number. Some did remark that Give-A-Number was not a game that could easily be played independently. Beading Towers was discussed and many teachers agreed that the versatile nature of Beading Towers was useful, though the many balls could make quite a mess, which could be remedied with the use of small bowls. A teacher reported that her students quickly understood that they needed bigger numbers to win when competing, and
reacted quickly when they rolled a big or small number. Finally, the teachers offered an abundance of constructive criticism regarding Math Bus, confirming the survey results and indicating that this game is one that can be improved. The most common criticism was that the game was difficult to alter so that it challenged children of higher knower-levels.

The information collected thus far through the surveys and focus groups illuminates how the games operate when a preschool teacher is the sole implementer.
**General Discussion**

Over the course of the production and evaluation of the Wesleyan Preschool-Math Curriculum, each stage provided us with information about what was successful and what was not. The curriculum has gone through many iterations and each stage informed us not only about the games, but about each method of development. The Teacher Feedback Study has provided us with insight into teachers’ experiences with the games, but the experience of orchestrating an evaluation study demonstrated how to improve upon our future assessment methods. As production continues, we plan to continue adapting to feedback, so that the games can continue to evolve and improve. We also plan to coordinate other forms of evaluation, specifically to determine the curriculum’s ability to improve preschoolers’ math skills over time.

The curriculum development was composed of three different methods and involved over 100 people. The source of development was in an undergraduate course setting, which proved to be advantageous to the process in many ways. Firstly, each time the course was taught, new and varied students were involved and could contribute ideas. Many students were not previously familiar with educational research, numeracy development, or preschool education. The diverse student backgrounds often lead to innovative and thoughtful feedback. For instance, a student in the 2014 iteration of Research Methods in Cognitive Development and Education learned English as a second language, which affected much of her early education. Her linguistic experiences provided her with insight as to how to alter the games so that children with fewer language skills could still participate and learn. Second, the development of the games occurred over nine iterations thus far, and six
of those iterations were completed by the students in Research Methods in Cognitive Development and Education. With each iteration, the games were improved upon and tested in a variety of settings by different implementers. This repetitive process resulted in increasingly refined games. From this method of development, we learned that a college course was an advantageous source of iterative design as it provides an abundance of diverse input and allows for the development process to repeat continuously.

The developmental iterations that occurred during the Wesleyan Summer Research Experience and as a Cognitive Development Lab project during the school year illustrated the benefits of a more focused approach. All focus was directed toward one game per week, and time spent using them in preschools was moved from weekly visits to daily visits. Due to the increased amount of implementation, the games were altered in a more practical manner. For instance, if one of the game materials was not working as intended in multiple settings, that material could quickly be corrected or altered. For example, the curriculum contains one board game that was originally covered in felt so Velcro pieces could be attached. Each research assistant who implemented the game with felt noticed that it quickly deteriorated as the game pieces were continually moved and reattached. Therefore, the felt was replaced with a magnetic strip. Cognitive development research assistants and preschool teachers were the sources of input during these iterations of development, which consequently resulted in less diverse, yet often more informed feedback. The concentrated approach resulted in a more detail-oriented form of development, which eventually lead to the current version of the curriculum.
The Teacher Feedback Study is the first time the curriculum has been evaluated using preschool teachers as the sole implementers. Previously, the games had always been run by undergraduate students involved in the development process, and the assessments of the games could be biased. This qualitative and quantitative data collected from the Teacher Feedback Study proved incredibly informative. The teachers have described responses to the games that the curriculum’s developers had previously experienced and recorded. For example, various research assistants and I noticed on multiple occasions that the children would play math garage repeatedly, often having to be asked to share with other children. One participating teacher reported a similar experience in a focus group, stating that she had spent hours playing math garage with her students in the past week.

The study has also made us aware of issues with the games that had never been noticed before. Nearly all teachers reported that the children could not recognize the numeral one as “1”. They could only recognize it if it was written as a straight vertical line, “|”. Now that we are aware of this issue, we can make a simple yet meaningful change by using the straight-line version of the numeral one in subsequent games.

This evaluative study has not only taught us about the strengths and weaknesses of the games, but it has also been informative regarding what does and does not work when organizing and conducting a feedback study. The first meeting included a presentation about the theoretical framework of numeracy development and education. The teachers actively asked questions and reported their interest in gaining a better understanding of what their students understand about math. For this
level of interest, it is surprising that the average amount of their previous professional
development or training in numeracy and math was rated as a 4.2/7. Throughout the
two focus groups that have been completed, teachers often mentioned knower-levels
(Wynn, 1990), the three counting principles (Gelman & Gallistel, 1986), and their use
of Give-A-Number as an assessment tool (Schaeffer, Eggleston, & Scott, 1974). Two
teachers assessed their students’ numeracy and collected a chart of their students’
knower-levels the following week. The level of interest indicated by the response to
the presentation shows a need for more professional development opportunities and
preschool math pedagogy.

The surveys and focus groups have provided important quantitative and
qualitative data, but could likely be improved. It is the first time we’ve used ratings
instead of open-ended evaluation methods, so the quantitative data has provided new
means of describing the nature of the games. Therefore, it would be beneficial to
include more questions in the surveys. These additions should include questions
regarding the average duration that a game held students’ attention, a rating of the
difficulty when played without alterations, and an estimated range of how easy or
difficult the games can be when altered accordingly. This information could provide
our existing responses about student interest and ability to potentially improve
students’ math skills with more depth.

Due to the nature of math games, there is always room for improvement and
growth, which we plan to facilitate. After the completion of the Teacher Feedback
Study and the subsequent alterations to any games, the curriculum would need to
undergo a study of its efficacy. The research basis, numerous rounds of alterations,
and teacher feedback thus far suggests that the games have the potential to help improve preschoolers’ numeracy in preschool. There is currently no evidence, however, that this set of games would effectively improve numeracy in preschoolers.

In addition to examining the outcomes of the Wesleyan Preschool Math Curriculum, the games should be implemented at preschools for children with special needs, such as at a preschool for Deaf or hard of hearing children. Originally, Research Methods in Cognitive Development and Education focused in part on the Deaf community, the recent iterations of the games have not. Previous implementation cycles have been conducted at preschools where the majority student are typically developing. Playing the games with a diverse range of students will likely provide new information about the range of responses to games, and could lead to a version of the curriculum designed specifically for Deaf or hard of hearing children, for example.

In the process of creating the Wesleyan Preschool-Math Games, we realized the impact that varied and abundant input can have, as well as what the different development methods were able to accomplish. The original and driving purpose of the games is to improve upon children’s numeracy and math skills – a step towards improving academic outcome. As them games are developed and evaluated, we are able to move towards this goal.
References


Clements, D., Copple, C., & Hyson, M. (2002). Early childhood mathematics: Promoting good beginnings. *A joint position statement of the National Association for the Education of Young Children (NAEYC) and the National Council of Teachers of Mathematics (NCTM).*


Purpura, D. J., & Lonigan, C. J. (2013). Informal numeracy skills: The structure and
relations among numbering, relations, and arithmetic operations in preschool.


Xu, F., & Spelke, E. S. (2000). Large number discrimination in 6-month-old infants. 

*Cognition, 74*(1), B1-B11.
Appendix A

Math Garage instruction sheet depicted on next page.
**MATH GARAGE**

*For 1-2 Players per set*
- This game has flexible materials for infinitely different rounds.
- Players park their cars in a spot with an array that corresponds with the Arabic numeral on the car.

**Materials**
- Sets of simple toy cars with Arabic numerals 1-10 on them
- Parking lot board
- Parking lot pieces

**Directions**
1. Set up the parking lots with the spaces numbered in consecutive, ascending order.
2. Place the cars several feet away and mixed up so they are not matching the parking spots.
3. Explain or discuss that this is a parking lot and the goal is to park the cars in their correct spaces.
4. Two children up their side of the parking lot. They can have the same numbers (i.e. 1-5) on both sides or different numbers (i.e. 1-5 and 6-10) depending on each child’s level.
5. Once all of the cars are parked, mix up all the spots so they are not in order and start again!

**Questions**
Throughout the game, you should prompt the children to discuss number. Here is a list of questions to start the conversation:
- How many cars are parked?
- Why does this car go in this spot?
- Which spot has the highest number? Which has the lowest?

**Variations**

*Make it easier*
- Work with one child and place the cars close to the parking lot
- Fold the parking lot sheet for less spots

*Make it harder*
- Race to be the first to get all cars on their side correctly parked
Appendix B

Preschool Math Survey

1) During you teacher training or subsequent professional development, how much formal training did you receive in math development or math education?

   (Very Little)  1  2  3  4  5  6  7  (Very much)

2) How comfortable do you feel teaching math in your classroom?

   (Very Uncomfortable)  1  2  3  4  5  6  7  (Very Comfortable)

3) How well do you think you know each student’s math abilities?

   (Not Well)  1  2  3  4  5  6  7  (Very Well)

4) On average how many hours a week do you spend on math in the classroom?

   ____________________ hours

5) Generally speaking, how interested are your students in math activities?

   (Not Interested)  1  2  3  4  5  6  7  (Very Interested)

6) Do you use a formal math curriculum (e.g. Building Blocks or Big Math for Little Kids)?

   Yes   No

7) Do you use the math portion of a comprehensive curriculum (e.g. The Creative Curriculum)?

   Yes   No

8) If yes, how well do you think thinks curricula addresses your math goals for your students?

   (Not Well)  1  2  3  4  5  6  7  (Very Well)
Appendix C

Focus Group Questions

Implementation:

1) When and for how long did you use the games? In what context?

2) How did having the games affect the amount of time you usually spend on math? How does it compare to the week before?

3) Was it easy to integrate the games in your classroom?

Student Response

4) How did your students respond to the game?

5) What kind of students were more interested in the game?
   a. Were the children interested in the game generally more skilled in math or less?

6) Did you notice any student interactions involving the games?
   a. Was there teamwork or competition?
   b. Did students help or correct each other?

7) Did you feel that the games were at the right level to help the students improve their numeracy?
   a. Were you able to adapt the games to fit your students’ needs? If so, how?

8) Were the games easy to facilitate?
   a. Could children play independently?

9) Were game instructions clear?
   a. Was the in-person demonstration effective?
b. Were the instruction sheets effective?