Pattern Blocks or iPads? Evaluating Teacher Tools for Early Childhood Numeracy

By:
Maggie Blackburn ‘12, Josh Fahs ‘12, and Christina Mazza ‘12

Augustana College
Rock Island, IL 61201

Since November of the 2010-2011 school year, the three of us, teacher candidates from Augustana College in Rock Island, IL, have been working closely with individual and small groups of kindergarteners from Longfellow Elementary School in Rock Island. Our main goal for this project is to use a variety of effective teaching materials and instructional strategies in order to improve the number sense skills critical to these young students' future math development. An additional benefit of the project is that we, as teacher candidates, are gaining additional professional experience. It has helped us gain a better understanding of how students' early math knowledge progresses and the effectiveness of various teaching strategies and materials. We have learned how to adapt these strategies and materials to the individual needs of each kindergarten student. Overall, this project allows for the growth of both the students and us throughout the year by providing extra math instruction for students and providing us with more professional experience.

Beginning in August 2010, we started working with the two kindergarten classrooms at Longfellow Elementary School as part of our requirements in the collegiate course "Teaching Mathematics in the Elementary School." After completing the course, we were given the opportunity to continue working with the children from November of 2010 to the end of the Augustana school year in May 2011. Each of us has devoted four hours a week to hands-on, individualized instruction for the kindergarten students. In order to foster students' development of early math skills, we have used and evaluated effective tools that aid our instruction and the students' learning process. Examples of tools we have found to be beneficial are math development software programmed on classroom computers, as well as on iPods and iPads purchased by the Augustana education program; classroom manipulatives such as counting chips, number cards, and BINGO games; and even the stairs around the school! The needs of each individual child determine which specific tools and activities we decide will be most beneficial to the students.

The wide variety of educational materials we have used and the range of children learning needs we have encountered have led us to wonder about which teaching tools are most effective for different teaching situations. For example, which tools work best for children who still struggle with counting to 20 toward the end of their kindergarten year? Which tools are optimal for challenging more advanced children who seem to have mastered kindergarten-level material? In order to focus these questions into a researchable project, we decided to focus our research on three crucial early number sense skills: counting to 32, number recognition, and one more/one less. These skills align with some of the goals from the *Kathy Richardson Assessment Series* (Richardson, 2002), which we have used to assess the abilities of several kindergarten students. After the assessment, we determined the level of knowledge these students possess based on Richardson's levels of student understanding. Richardson evaluates students' progress by placing them into three different categories for each number sense concept; these categories are: needs instruction (the child is beginning to learn the concept and needs more exposure to it), needs practice (the child is close to fluency with the concept but makes occasional mistakes), and ready to apply (the child is fluent with the concept).

What is Number Sense?

We have researched and evaluated additional definitions, instructional strategies, and assessment tools for primary grade number sense. There are various opinions regarding the specific aspects of number sense, as well as the use of technology during instruction of number sense concepts. While different researchers define number sense differently, there are some consistent understandings of this concept in the literature. For instance, an operational definition from Van De Walle (1990) as cited in Lago & De Perna (2010, 167) is, "Quantities (more and less, one-to-one correspondence, cardinality, ordinarily, understanding of the relative size of numbers); estimation of set size; comparison of set sizes; and counting." A more recent operational definition of number sense from Jordan, Kaplan, Olah, and Locuniak (2006) includes skills such as counting, number knowledge, number transformation, estimation, and number patterns. The similar elements of these operational definitions of number sense are counting with cardinality principles, estimation, number knowledge, and number transformation by adding one and subtracting one to various numbers. Based on these similarities and the Richardson Assessment (2002), we arrived at the decision to focus on counting quantities, number recognition, and one more and one less of a number.

The basic foundational skills of number sense are crucial to the development of kindergarteners; they will continuously use these skills as they progress into the more challenging aspects of number sense and math in later grades. The various skills that almost all basic operational definitions of number sense have in common are important throughout the primary grades of elementary school, but they truly begin to develop in kindergarten. It is vital for these young students to know and understand these initial skills, and if they are unsuccessful, it will impede their later learning. Growth and performance in number sense skills could "account for up to two thirds of the variance in first-grade math achievement" (Rasanen et al., 2009, p. 452). There is a necessity for students to learn number sense skills because if kindergarten students are not catching on to these ideas, they begin falling behind classmates early.

As previously mentioned, each of the articles we reviewed during this project included counting with the cardinality concept, estimation, number knowledge and recognition, and number transformation as important components of number sense. Counting quantities (up to 32 objects), number knowledge (recognizing numbers), and number transformation (specifically one more/one less) are the three components we focused our research on for this project. Our formative assessments since the beginning of the project of students' math skills, along with completing the Kathy Richardson assessment with several of the students, have helped us understand the skills kindergarteners should have in each of the key aspects of number sense. We used her classifications of students' skills to evaluate whether students are able to apply each number sense concept, need more practice with that concept, or need instruction on that concept. Counting is one aspect of number sense that everyone knows is an important part of kindergarteners' development in math, but there are several different ways to assess students' counting skills.

Jordan et al. (2009) state that the components of counting as a part of number sense are: grasping one-to-one correspondence, knowing stable order and cardinality principles, and knowing the count sequence. These are all counting skills that we have helped the kindergarten students develop throughout the year by using various activities and resources. Most kindergarten students in the two classrooms at Longfellow are ready to apply the concepts of counting up to 29 objects (and beyond for some) with one-to-one correspondence, counting out about 29 objects (and beyond for some), understanding cardinality, and knowing the count sequence to 29 and beyond with and without counting objects. Number knowledge, specifically recognizing numerals, is also an area of number sense many people understand as an important part of kindergarteners' math development because almost every kindergartener spends a large amount of time learning the different number symbols and practicing writing these symbols.

The majority of the students we worked with are ready to apply the concept of number recognition up to about 20, and again beyond 20 for some students. For the concept of one more/one less, most students are able to apply this knowledge up to one more or less than 10, while some can answer one more/less than a number over 100. These claims are based on our assessments of student skills in the kindergarten classrooms that began in the fall of the school year and became more prevalent in the winter, and throughout the remainder of the school year, we have documented our formative assessments of the kindergarten students in blog posts[1], assessment sheets, and video footage.

The Role and Rationale of Technology Use in the Number Sense Project

Even prior to the 21st century, researchers have been studying the effects of multimedia environments on students' mathematical success. Multimedia is a way to make learning experiences more meaningful to the child by combining media together for active learning to take place. Weiss, Kramarski, & Talis (2006) mention the impact of a multimedia in cooperative learning and individual learning as well as a control group who was not exposed to multimedia. Teachers may believe that computers may be too complicated for students to manipulate; however, in this century, students need to learn how to use this form of technology. Benefits of multimedia environments are that children can build mental images from media, which includes pictures, words, and sound as opposed to just words alone on the piece of paper. The way students learn comes from exploring and making their own meaningful discoveries which is the reason why multimedia was designed. Multimedia can be used to increase the understanding of basic number sense concepts such as number recognition, counting, grouping, comparing numbers, and adding one more or one less to a number. Overall, they found that kindergarten students that studied using the multimedia in both group and individual settings outperformed the control group at each level of math computation skills.

Weiss et al. (2006) also found that individuals using the multimedia scored higher than the cooperative groups using multimedia for higher level skills such as estimation and adding and subtraction. This may be due to the fact that the kindergarteners in the cooperative groups had poor communication skills. However, it was found that when students work in cooperative learning environments it increased the students' outlooks on the subject and made the learning experience more enjoyable, which implies that students should be encouraged to do group work due to the positive social and educational outcomes. This study reveals that multimedia learning where students can make real world connections and receive instant feedback from the technology about their learning progress is the most active and meaningful way for these students to learn math. The reason why multimedia environments are shown to improve students' mathematical understanding is because this type of environment allows students to be actively engaged in their learning, which makes the information more meaningful and therefore students remember the information better.

Technology can be used as a conceptual support by allowing words and numbers to be represented by images. For example, in many math computer software games, numbers and words are represented by kid friendly images and allow students to use images to solve certain problems. Technology can be used as a communication tool by allowing students to communicate with others and the instructor by asking questions about why they performed a certain task; some students even engage in self-communication by speaking their thoughts and strategies out loud. Technology can also be used as a problem-solving and decision making tool by having students solve problems and make informed decisions.

The advantages of using technology as a tool are that it provides an engaging environment by learning through software, provides various specific programs that target individual needs, and provides colorful, interactive, and competitive visuals that will grasp immediate attention. As an instructor, technology allows you to manage the rate and sequence of students' learning depending on the students' ability level. Many people place a high value on the use of technology and therefore have high expectations for it as a tool for student learning; however, technology is not magic and will not automatically provide your students with an increased amount of knowledge. Games need to

[1] http://www.augustana.edu/blogs/numbersense/

be evaluated before allowing students to use them in order to make sure they are effective because some students require more structure and may become easily frustrated and need further instruction (Smaldino, Lowther, & Russell, 2012).

The major decision lies in determining what kind of tools are most beneficial for the individual learner. Although technology receives "ohhs and ahhs" from the students and the iPad is a tool they love to work with, for some students it's simply not effective. Students who are struggling with a number sense concept need to explore the topic more and get a base understanding before they apply their knowledge to use these programs. An app cannot provide the best base understanding of a concept for students because it cannot explain and cut in to correct mistakes like an educator. In order to make technology the most effective tool for each individual kindergartener, we have learned how to work with the disadvantages of technology and make them minimal. For example, a disadvantage of technology is that it sometimes lacks structure and focus on individual needs; therefore, during our weekly number sense meetings, we collaborate on how to modify our math computer software better fit the needs of specific student needs. An additional disadvantage occurred as we observed the students struggle to complete the task of a program not because of their abilities, but the touch screen on the iPod became too challenging and frustrating for some of these young students while completing the task; therefore, we placed a request for each iPod to include a stylus so the students were more concerned with their responses rather than maneuvering the software on the iPod. Also, an iPod is designed for more of a personal use and it was not conducive for us as we tried to observe the students' methods of thinking and responses on the iPods. Our use of the iPad as a tool for the kindergarteners to use began after our advisors mentioned how useful a larger touch screen would be for the students to use and to see the programs. Both tools are beneficial, but for younger students, an iPod's screen might just be too small. We also discuss new program ideas based off of a common area of concern amongst the kindergarteners, which were developed and coordinated by Dr. Randall Hengst, a Professor at Augustana College. Using manipulatives when working with the kindergarteners encourages students to become responsible for their own learning and using their own strategies, unlike some technology. Providing the student with the correct answer rather than allowing them to try again on their own, is a flaw that some technology programs might include.

Rasanan et al. (2009) suggest that computer-assisted interventions may never replace the book and the blackboard but one should be aware that they are more accessible by young children, who learn better with pictures and sounds, and the proper use of appropriate programs could make a considerable difference. As technology becomes more prevalent, students begin to take advantage and utilize technology at younger ages, and are gaining more from the proper use of it than in earlier years. The impacts and benefits of the iPod and iPad technology became one of our concerns as we observed the kindergarten students utilizing them in their learning. Due to the increase of its presence in society and lives of young students, technology has a greater presence in the lives of some students than others, and these students may be more comfortable than others using technology. There are also a few typical requirements of technology that have been regarded as important: "(1) The machine must present information in the form of a task, (2) it must provide some means to respond, (3) it must provide feedback about the correctness of the response... and (4) The system should be able to adapt the task conditions online to maximize learning" (Ransanen et al., 2009). The technology we provided for the students to utilize as a part of our research, which met the above criteria, was the Number Sense software designed by Dr. Hengst, as previously noted above.

In working with the kindergarteners, we were interested in how computer technology might enhance their numerical understanding. As Longfellow School has a significant number of English Language Learners (ELLs), we were also sensitive to ways that technology might benefit these particular students. Kim & Chang (2009) explored the effect of computer use in different situations on students from a variety of backgrounds. This particular study split grouped students into two language groups: English only students and ELL whose primary language was not English. There were three variables used to study computer use in elementary students, including computer use for mathematics. Computer usage for various purposes had an overall positive effect on all students, with English speaking students gaining more benefits overall. The most relevant result to our own research, and therefore the most interesting to us, was the effects of computer use for mathematics. Computer usage for math was found to reduce the performance gap in math between English-only and ELL students, which could be seen as positive because of the positive effect on ELL students, or a negative due to the effect on English-speaking students. It is interesting to see the effects of the different variables researched in this study on students' math performance, and a closer look at the results could also gain more focus on this topic. A question raised is whether or not the high-achieving math students are being challenged enough, which is why the option to alter the settings, such as our Number Sense programs includes, is crucial in creating effective software. We found that the students must have an understanding of the concept prior to using mathematical programs, which in turn allows them to perfect the concept and their skills in this area.

The extent to which kindergarten students learn number sense skills, an explanation of what is considered to be effective technology, and how we implemented technology into our research have been discussed thus far; therefore, we will discuss the ways in which these young students use technology to increase their number sense skills. To maximize effectiveness of early intervention programs, Lago & De Perna (2010) mention in their research how teachers must identify critical skills that promote later mathematics proficiency. The data gathered can be used to design and modify interventions to maximize effectiveness. The software that is aimed towards the development of the number sense skills was used during our research in order to promote proficiency in math.

Research

Number Sense Skill: Counting Objects

For each of the number sense concepts we focused our research on, we eventually chose three students from each kindergarten class to spend extra time with working on that concept. We chose these "focus" students based on our previous assessments and results from the Kathy Richardson assessment series in order to study the effect various teaching strategies and materials have on the learning of students with different skill sets within the same number sense concept. For each of the concepts of counting to 32, number knowledge, and number transformation, we chose a student ready to apply the concept, one needing practice with the concept, and one needing more instruction on the concept; this focused our research for each concept onto three students from each of the two kindergarten classes, or six students per concept.

As previously mentioned, there is a wide range of counting skills between students in the two kindergarten classrooms at Longfellow, but the majority of students are able to rote count and count objects to at least 29. However, the range of counting skills spans from students still struggling to count ten objects to students able to rote count and count objects to 100 and beyond. We have observed this wide range of counting skills throughout the year and formatively assessed students from both kindergarten classrooms on this concept using the strategies and tools discussed previously. The students that are ready to apply the concept of counting to 32 show they are comfortable counting objects to 32 and often far beyond that point.

A student at the needs instruction level like Student E1 (we have given pseudonyms to all students discussed individually in order to keep their anonymity), cannot count fluently past ten and has not been able to despite the additional help she has been receiving. Both rote counting and counting objects are difficult for Student E1, but when she begins to count objects, she frequently becomes distracted. While counting, after she gets to ten, she will just give up or say random numbers. Manipulatives have been used, counting stairs, counting squares on the carpet, and using the iPod, iPad, and computer have been used to help her, but she never appears to be interested enough to want to learn the numbers. The most frequent use of technology that Student E1 uses is using the program *Count Sort*[2] which requires her to count the dots as she touches them and they change colors. The maximum number of chips is often lowered for her compared to the other students, so she is counting up to 20 or 25 chips rather than 32, which is the highest option, and she has difficulties coming up with the lower number options sometimes. We usually begin using manipulatives in order to get her familiar with the numbers and give her some base knowledge prior to gradually moving to the iPod or iPad. She has difficulties with the programs, but it helps her to continually practice the skills it offers, as long as she understands the basis concept of the skill.

Student J1 has not made much progress with this concept over the course of the year. He has consistently been unable to count correctly up to 10 since the beginning of the year. At the beginning of our work, as well as during our most recent work with him, he says the numbers 18 and 19 after the number 7 every time he counts, unless he is reminded while he counts. Without the skill to count to or beyond 10, this student has been unable to apply the skill of counting to other number sense concepts, such as number recognition and more or less. He has even been inconsistent recognizing numbers up to 5, and the concept of more or less is too challenging for him without more knowledge of the counting sequence. The positive part of his counting skills is his ability to correctly count one object at a time, which sets the foundation for more development as he learns the correct counting sequence. This student has been an example of neither technology nor manipulatives working well to help him develop counting skills. As with student M1, technology has a greater potential to benefit student J1 because of the higher level of engagement it provides. He becomes very distracted when uninterested in what he is learning, but the technological resources we have used have at least kept his focus for a longer period of time to create more learning opportunities.

In the needs practice level, Student M1 can fluently count out objects up to 32, so we had him rote count to see how successful he is when counting higher numbers. He can count to 100 and can count by fives but when counting, there were a number of occasions where he would either forget or hesitate when a ten was next. For instance, after 59, he would hesitate and had to think for a while that 60 is the next ten. Since Student M1 should work more on fluency so it seems more natural than forced, slowing him down so there is time to think might allow time to trigger his memory of what ten is next. If asked to begin at a higher number, he hesitates and takes it slow until he catches on and begins rushing through the numbers again. When working with the *Count Sort* program, the highest option is 32 and Student M1 can count higher, but it is helpful because it is difficult to rush through the numbers as quickly as when rote counting. Taking time to count each object also increases the ability to choose the number of chips. For this particular student in this level, he needs practice in knowing the numbers and feeling confident in that, rather than rushing through the numbers because then he would be less likely to forget the ten that comes next.

Student M2 has shown much progress with both rote counting and counting objects skills over the course of this year. At the beginning of the year, this student was able to count to 29, but he consistently made several mistakes counting between 10 and 20. These mistakes included

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[2] Access to each of the number sense programs is available at www.augustana.edu/numbersense.

skipping the number 15 almost every time he counted, then usually jumping from 15 to 17. This student can now consistently count beyond 20 objects but still needs some practice counting up to 32, as shown by his results from the Kathy Richardson Assessment Series. He now has some trouble beyond 20, especially remembering the number 30. However, he was able to successfully order number cards up to 40 during our most recent instruction with him. This included some mistakes between 10 and 30 due to number recognition, but he was able to use his counting knowledge to self-correct these mistakes. More impressively, he was able to order 30-40 correctly with no assistance. He is very close to being completely ready to apply his counting skills to other number sense areas, as shown by his recent success recognizing and ordering numbers up to 40. If it were not for the few mistakes he consistently makes while counting beyond 20, he would be ready to apply this concept. Technology has been more successful helping this student's' counting skills progress, because the technological resources, from a computer to an iPad, have been much more engaging for him. He has had consistent problems this year staying focused when working with manipulatives, but even teaching the same concept using technology has seemed to make a much larger difference in his learning, which will consistently be a solid argument for the use of technology during math instruction.

An example of a student ready to apply the concept of counting to 32 and beyond is student J2, who has developed an ability throughout the year to count correctly to 32 when she does not rush through counting. Through various forms of assessment with student J1 this year, we have seen progress made from skipping the numbers 14 and 15 when counting to 20 early in the year, to successfully counting to 32 and applying this concept to help her recognize numbers to 20 and beyond, understanding one more, and adding on to previous quantities. Her results from the counting portion of the Kathy Richardson Assessment Series showed an ability to count correctly to 32, and a recent activity ordering number cards showed she can count well beyond this point, up to 60 and beyond. This student has benefited from the use of both manipulatives and technological resources during math instruction. She does seem to have benefited slightly more from using technology because most of the tools she has used require her to take her time while counting in order to touch or drag every object she counted. However, some manipulatives, such as number cards, also force her to count more slowly in order to correctly order them. Any time she slows down to count, she is able to correctly count well beyond 32. As with several of the students we have worked with, both manipulatives and technology have been successful helping this student practice and apply her counting skills.

Since the beginning of the school year, Student S1 has been a part of the ready to apply stage due to her strong counting ability. She was successful in one-to-one correspondence and rote counting, and when given any number, she could match the correct amount of manipulatives. Due to her ability, we differentiated her learning compared to the other students and worked on additional number sense skills and math skills such as addition, subtraction, and word problems was her main learning priority. However, Student S1 was given the *Count Sort* program to use on the iPod or iPad in order to make sure she could recall the information of counting objects effectively. Her level of counting is higher than a majority of the other students and with more fluency. When she counts to 100 and higher it seems more natural and without much distress; she can also comfortably count by 5's and 100's. Student S1 assured us that she could count to 424 if we wanted her to, but we just decided that 132 would be just as fine. She doesn't seem to have problems past one hundred when applying the words 'one-hundred' before each number because she is connecting the numbers prior to one hundred to the numbers post 100. Student S1's skill of other number sense skills also parallel with her skill in counting, giving her well-rounded number sense knowledge.

We have concluded that the use of technology such as the iPod, iPad, and computer seems to have a stronger effect on the students' ability when working on their counting objects skill. For the students we worked with at the needs instruction level, success was more prevalent when they used technology compared to the use of manipulatives with the students. The iPad was more appealing to the students, which made the students more willing to count the chips on the screen, rather than the manipulatives in front of them. Those students at the needs practice and ready to apply level showed benefits and success from technology and manipulatives; however, technology has shown a greater success for this group of students when counting objects. When demonstrating their knowledge through rote counting, they seem to have more mistakes because they rush; when they work with the iPad program, they are forced to take their time, which improves their counting. This initial practice of counting slower helps to solidify their understanding and correct what mistakes they do make.

A reoccurring benefit for all the levels of students is the fact that technology like the iPad has a higher level of engagement for students than the use of manipulatives. Additionally, the *Count Sort* program we used in our research requires students to take their time, since the program can only go so fast. Even for those students who are at the ready to apply level, some mistakes still occur when counting too fast, which is why technology can encourage them to slow down and take their time focusing on the task at hand.

Number Sense Skill: Number Recognition

When focusing on the number sense topic of number recognition, we asked various kindergarteners to recognize the number symbols from 1-32 and then count the specific quantity using chips. Based off of the results we received with number recognition, we chose to work with six students: two students at the needs instruction level, two students at the needs practice level, and two students at the ready to apply level. By focusing on six students at three different levels, we were able to identify effective tools and strategies for these individuals as well as understand any inhibitors that could explain why they currently are not successful within this skill.

When working with the two students at the needs instruction level, we focused on helping these students master counting objects and become familiar with the numbers 1-10. These students really struggled with number recognition and showed inconsistency each week when stating the name of numbers. When selecting beneficial tools for this level, we think that manipulatives and hands-on learning worked the best. The hands-on use of numbered flashcards showed students the name of a number, and asked the students to perform a task with that number, such as a movement (e.g., for the number 5, ask the students to hop in place 5 times). This would foster development of both number recognition as well as rote counting. Because these individuals have a good understanding of numbers 1-5, we created a modified version of number bingo using numbers 1-8 and 1-10. This activity allows students to practice number recognition and also allowed me to record any number recognition strategies these students possess. For example, since one of the students has completely mastered recognizing numbers 1-5, when we would ask her to place a chip on number 6, she would use process of elimination by pointing to numbers 1-5 and then deciding between 6,7,and 8 by considering only those three remaining numbers. When attempting to engage the students every student loves using the iPod because they forget that they are learning and refer to it as simply playing games. However, we immediately found that when working with students at this level it is sometimes hard to use some of the software because it was too advanced for these two students' level of understanding. For example, students at this level were often unable to recognize numbers from 1-10. This makes the programs on the iPad involving number recognition too challenging for these students, since they often require students to recognize numbers up to 20 to successfully complete the activity. *Count Sort* can focus on numbers below ten, *Ah Chute* focuses on numbers 1-5, and *What's Hiding* and *Pattern Sets* can focus on one to five. The students need instruction on this topic and the software programs we used require that students have a basic understanding for the topic and serve as a review and practice.

Therefore, we decided to alter a basic program called *Line Em' Up*, which is a number line task where students have a number line with some numbers already on the line but then the student needs to place the remaining numbers on the line. This program was originally designed for students to work with numbers 1-20; however, due to the needs of these two kindergarteners we modified and created an option that would allow the students to only work with numbers 1-10. With students at this level, we can't just let them take the iPad and use the software alone; we normally provide instruction and feedback while prompting the students to perform certain tasks. For example, when these students engage in *Line Em' Up ,* we normally ask them to first tell us the number that they are asked to place on the number line and then provide them with strategies in order to figure out where to place that number. This is done because otherwise some students become frustrated when they try to place a number in the wrong spot at first that they lose confidence and just try and place their number in every open spot on the number-line. One time when the student was severely struggling, we let him use a printed number line from 1-10 so he had the answers in front of him but he still had to use the printed number line as a tool to help him complete the *Line Em' Up* version; this allowed the student to become very confident and successful because the student then succeeded at completing the program.

Normally when playing this program, we prefer that the students are challenged, by changing the options, while playing *Line Em' Up* in order for them to learn and benefit from the software. However, since these students are at the needs instruction level, the clues that technology provides them by already supplying some of the numbers on the number line and providing spaces for the numbers to go in the students are able to gain experience with ordering numbers.

When working with the two students at the needs practice level, these students could almost correctly count out 32 chips however both students only can recognize a little more than half of the number symbols from 1-32. When we asked each of the students to order the cards that contained numbers 1-30 on them, both of them were successful even though they needed reassurance and a lot of time to complete this task; this shows that they do have a general understanding of number patterns in order to complete the task. However, when we asked one of the students to then show us where 24 was among the numbers that she had laid out in front of her she responded, "That number is not out here." When we asked the other student the same question she pointed to 14 and then knew that wasn't correct but then didn't know what 24 looked like. This shows that the students can perform some of the tasks and know where some of the numbers are after repetition or after working on these activities for a while; however, number recognition to 32 has not become automatic and mastered yet.

When using technology with these students, we use various software programs on the iPad. The game *Line Em' Up* focuses on number recognition and placing the numbers 1-30 in the correct chronological sequence. *Line Em Up* has settings that allow teachers to select a range of numbers anywhere between 1 and 30 to have students work with; this allows for differentiation and allows us to use the iPad with students who are only working on mastering number recognition and sequencing with numbers 1-10. After selecting the setting, the iPad will draw out a number line and place some of the numbers in their spot and then prompt the students to drag the rest of the numbers to its correct spot on the number line. We have discovered that the students can almost always successfully complete this game because they realize the patterns that they see in numbers even if they don't know the correct name of the number. For example, the student knew to place 14 in-between 13 and 15 but then when we asked her what number she had just put in its correct place she had to count from the beginning of the number line in order to tell me that it was number 14.

We also use the *Count Sort* software program, which involves counting, estimating, and sorting chips. This software program also has settings that allow teachers to select the range from quantities of 10-32 chips being counted, estimated, or sorted. We mostly used the counting option with the kindergarteners where they would be asked to count the number of chips that appeared on the screen and then select the correct numeral answer that corresponded to the number of chips they counted. *Count Sort* allows students to practice using one to one correspondence while counting as well as numeral recognition when deciding on the correct response.

Overall, both of these students have mastered 1-10, and know some of their teens and twenties especially after repetition. For example, one of the students didn't know the number 23 that was on a flash card, so after we told her the number, we then showed her 27 and she was able to correctly state that it was number 27; this student was able to realize the similarities in 23 and 27 and realized that they both were in their twenties and then she just changed the ones number to seven, since she already knows the name of that number. When working with students in this level of instruction, we have found that it is most beneficial to use technology and repetitive activities because these students need not so much of the instructional aspect of this number sense skill but rather the repetitive practice with any game or task that involves recognizing numbers.

When working with the two students at the ready to apply level, we focused on challenging these students to think abstractly about numbers and number patterns. Both of these students could automatically recognize numbers from 1-60 that were on flashcards. We used the game *Count Sort*, which would ask students to count a quantity up to 32 and then give the students four possible solutions to choose from as their answer. This required the students to be able to correctly count the number of chips and then recognize the correct answer from the given options. Both of these students excelled at the *Count Sort* game, so we decided to come up with our own game to challenge them to think more abstractly about numbers.

We provided each student with a piece of paper that said 6, 16, 26, 36, 46, 56, and 66 and then asked the students to say all of the numbers; the students were able to correctly state the names of the numbers. When we asked the students if they noticed a pattern with the numbers they were able to provide some sort of answer, as in they all ended in the number six. When we asked each student to complete the pattern, both individuals were able to write 76, 86, 96, and 1006. We wrote "1006" because that's how both individuals wrote the number 106, which makes sense because they wrote 100 and then added on a 6. This shows that these two students can not only recognize higher numbers, but can produce these numbers and continue the pattern based off of a pattern that we had given the students. After we worked on number recognition concepts with the students, we would select a higher level thinking game from the iPad for the students to use. For example, these students both correctly were able to use the *What's Hiding?* program, which requires the concept of basic subtraction and problem solving. Students are given an amount of dots up to ten and then only some of the dots come out from the box and students are to answer how many dots are still hiding under the box. Since these students are at the ready to apply level for number recognition, when providing them with a tool like the iPad, they usually do not need help with the various programs since they excel in various number sense skills.

These programs allow the students to gain extra practice and after working with these two students we decided to try and make some challenges to some of the programs. For example, we thought of a scroll option on the *Line Em Up* program so that the students could be quizzed on numbers 1-100 on the number line for those who have a developed sense of number patterns and number recognition such. There could also be a program that requires you to finish the sequence of certain number patterns, which would allow teachers to see if students truly know their numbers and can apply their knowledge of the patterns in numbers 1-30 to higher numbers. Overall, we used technology for review with number recognition topics and to gain practice by using other software that required higher level thinking while using manipulatives and pencil and paper for tasks that we wanted to see what the students could produce by themselves.

Number Sense Skill: One more/One less

This number sense concept skill encourages students to refer to number order and to begin understanding the concept of addition and subtraction. If students can demonstrate their knowledge of one more, one less, then they will be able to form a base knowledge of adding to and taking away from numbers. Based on Richardson's levels of understanding, students who need instruction are just beginning to grasp the concept, most likely because they are still behind on other number sense ideas such as number recognition and counting. Whether it is the phrasing of 'what's one more than eight or what's one less than five' that is confusing for the kindergarten students, or simply thinking of the one more, one less than concept, these students have not grasped it yet. These students also need more exposure in order to continue learning the concept, which is where either manipulatives or the software on the iPod and iPad become useful.

Student J3 was one student at the 'needs instruction' level for the one more/one less concept. Throughout the year she began to increase her skill in identifying numbers, but was not fluent or confident in her counting abilities, which makes one more, one less difficult. For example, in video footage shot in April of the same school year, Student J3 frequently skips the number 13 when counting objects; since a student cannot confidently count up to 20 in kindergarten at this point of the year, it is also likely that she will have trouble determining the value that is one more or one less than a given number. When given the Richardson assessment for number recognition and counting and after looking over her teacher's assessment of the students, we concluded that we need to focus more on these tasks, and gradually incorporate one more, one less. Since this student was in the needs instruction phase, we used manipulatives to help her with one more, one less skills rather than technology. When given manipulatives such as marbles, we would take one away or add one and then ask Student J3 for the answer. Then, we decided to only show her a number card and then ask what one more and one less than that number is, rather than continue with marbles because she was counting the marbles instead of calculating the correct number. She was successful with numbers under ten, but needed the assistance of marbles for numbers above ten. There was however, not a program in the Number Sense technology that specifically focused on one more, one less; therefore, the technology used for this student who needs instruction focused on other skills. However, we have discussed with our professor ideas for a new program that would help such students.

Another student who needs more instruction with the one more and one less concept is student N1, whose Richardson assessment results showed some success answering one more and one less questions between 1 and 20, but only when counting. She does not automatically recognize the correct answer for one more or less than a given quantity, and this assessment showed she also incorrectly answers for one less than some numbers between 1 and 10, such as one less than 6 (answered 7). Similar results were seen from this student with our formative assessments throughout the year, as she showed some understanding of one more, but little understanding of one less. However, our most recent instruction and assessment with this student, after she completed the Richardson assessment, showed more improvement with this concept. Although she still preferred to count to find one more or less than a quantity, she was able to more consistently answer correctly for one and two more, and even consistently with one less. She still needs more instruction with this concept, but she is making progress and will soon be closer to the level of "needing practice," rather than "needing instruction." With this student, individual instruction with the technological resources we have used has benefited her skills the most. The improved engagement level created by the technology, along with eliminating distractions with individual instruction, has proven to help this student focus on the learning process and improve her abilities with each number sense concept, including one more and one less.

A student who fell in the needs practice range, is close to being fluent with one more, one less but makes occasional mistakes. This student, identified as Student A1, was having difficulty recognizing numbers but was successful counting objects, and therefore was also successful at the *Count Sort* Number Sense software. When given the Richardson assessment for one more, one less towards the end of the school year, she correctly answered 'one more' questions, but had more of a difficult time responding to the 'one less' questions. Student A1 was first given problems beginning with numbers five and below, ten and below, then twenty and below, which is where her mistakes were. While answering the problems, Student A1 had to use her fingers to count down, and she also used a strategy of counting to the given number, thinking of the number she said beforehand and would be able to provide the answer. These strategies are not incorrect since it furthers her development, but they demonstrate that she needs more practice in certain areas. Even if Student A1's answers were incorrect, they did not stray by more than two numbers away, which shows us that she understands the concept, but is just not fluent with the higher numbers in the teens and twenties. This student was also able to correctly respond to two more, two less problems for numbers below ten while participating in *Just the Facts*, but once again, used her fingers to assist her in responding to higher numbers. Tally marks are shown next to the numbers in *Just the Facts* which also helps students solve the problems. Student A1's skills were successful and on target for her age, but she can still work on her fluency.

Another example of a student who needs some more practice with the concept of one more or less this year is student A2. This student showed on the Richardson assessment that she has developed the skill of adding one more to a number, but she still needs practice with one less than a number, as she always counts when figuring out what one less is and her answers are not consistently correct. Throughout the year, she has improved some with this concept, as she can now answer questions about one less more consistently, but she still misses some, such as one less than 13 on the Richardson assessment. She also still wants to count any time she is asked about one more or one less than a quantity; she does not have automatic recognition of what one more or less than most quantities would be. Learning and becoming comfortable with this concept may be the key factor to her being fully ready to apply this concept. During our instruction with this student throughout the year, she has benefited from both technological resources and manipulatives, but she seems to understand the more or less concept better by using concrete manipulatives, such as counting chips or marbles, to show what one more or one less than a given quantity is. It may be best to use these types of materials, rather than technology to help this student improve her skills using the more or less concept.

The ready to apply stage, demonstrating that the child is fluent with the one more or one less concept, is represented by Student Z1. This student has been more successful than a majority of the other students in the classroom throughout the year when it comes to all math concepts. In early December of the school year, Student Z1 could correctly, and without hesitation, answer each problem for the *10 Frame Fill* program previously mentioned, along with lining up 1-20 on *Line 'Em Up*. Student Z1 was frequently provided with the technological tools in order to hone his skills in the various mathematical areas. An additional program, entitled *What's Hiding?,* assists students in understanding subtraction without the association of the title, subtraction. This program was rarely used for students who were not a part of the ready to apply stage, or sometimes the needs practice stage, because of the difficulty in understanding that when only some of the hidden objects come out of hiding, that there are still some left in hiding; the goal is to correctly answer how many are left in hiding after first counting how many went into hiding and then came out. Since this success was documented in December, Student Z1 was more advanced than other students and was challenged with programs such as *What's Hiding?*, especially when the options to a 10-frame rather than a 5-frame was chosen. Student Z1 also correctly answered two more, two less questions using *Just the Facts* and when given a number and asked what two more or two less than that number was, he answered without much hesitation; some numbers were instant responses while others required a few seconds of thinking. His success rate and fluency are beyond target and more advanced, and he can utilize the advantages that technology brings to the one more, one less skill.

Student N2 has demonstrated a high level of skills in each aspect of number sense since the beginning of the year, even beyond the more advanced concepts of one more or one less. The first time we worked with this student, she showed an ability to count easily to 30, along with good organizational and one-to-one counting skills. Once we had formatively assessed this student a few times and found she was completely ready to apply her counting and number recognition skills far beyond 30, we advanced to focus on the concept of one more and one less. Early in the year, this student was able to easily answer "one more than" questions, but she was inconsistent with questions about two more than or one less than various quantities. She has progressed even more since then, as she is now capable of consistently answering two more or less than a number correctly, as seen on her results from the Richardson assessment. Recently we have been able to advance into simple addition and subtraction without the use of concrete objects to add or subtract. This student is also able to automatically answer when adding or subtracting one or two, which proves she is ready to apply, and can apply, her skills in the concept of one more or one less. She has benefited from instruction with both manipulatives and technology, as long as the tool being used challenges her abilities and keeps her motivated. Activities using tools ranging from marbles to practice more and less to the iPad to practice simple addition and subtraction facts have all helped this student expand her number sense skills, especially her understanding of more or less.

From focusing on these students and striving to improve each of their number sense skills with the concept of one more or one less, we found both technology, such as the iPad, and manipulatives, such as marbles, useful in aiding students' learning of this concept. Deciding which resource best helped students learn depended on the specific student, his/her skills, and the specific resource being used. For example, one of our focus students at the 'needs instruction' level benefited from her increased engagement using the technological resources, while we could not find a resource on the computer or iPods to help our other focus student at this level learn and improve her skills with this concept. Both of the students at the 'needs practice' level benefited from using technology to learn the one more or one less concept, but this was often because the technology often included "concrete" objects, such as tally marks during the *Just the Facts* game. These concrete objects, which also included students using their fingers to count while using a technological resource, were important to these students correctly answering questions about the one more/one less concept. The students at the 'ready to apply' level also benefited from both manipulatives and technology, as long as their skills were properly challenged with either type of resource. They often benefited slightly more from the technological resources because of the added engagement they provided, but there are obviously also teaching strategies that can engage these students without the use of technology. One main strength of using technology with students at the 'ready to apply' level is the efficiency it provides; these students are capable of understanding and using technology independently and getting much extra practice without the direct help of a teacher. Overall, although both technology and manipulatives can help students at all skill levels learn the one more or one less concept, students at the 'needs instruction' and 'needs practice' levels seem to benefit more from manipulatives because of their concrete nature, and students at the 'ready to apply' level seem to benefit more from the increased efficiency and engagement provided by technology.

Conclusion:

Prior to this experience of working closely with kindergarteners, our only other experience was in the beginning of our 3rd year at Augustana, when we worked with them on a few occasions as a part of an Education Methods course entitled "Teaching Mathematics in the Elementary School." In this class, and other mathematics classes, and during our work with the young students, we realized just how difficult it actually is for students to learn the beginning components of these concepts. As many people can probably attest to, it is easy to forget how we arrived to where we are currently regarding our knowledge in math. Working backwards and trying to discover new and different ways to explain number sense skills to students was a challenge for us due to the range of abilities, which also required much differentiation depending on what level students would fall in: needs instruction, needs practice, or ready to apply. Along the way, we eventually discovered and discussed the various methods that would and would not work for certain skills and certain students, which widened our array of knowledge regarding ways to teach number sense to young kindergarten students. Being able to discuss and learn these ways with our professors was also beneficial since they have many years of experience, and we are still students at the end of the day.

The technology aspect of our research was very interesting and exciting for our professors, us, and the students. We have been aware of the many benefits technology provides for us as students, and we were exposed to a limited amount when we were younger; however, observing these young students take to the iPod and iPad as quickly as they did was fascinating. Without any direction as to how either of them worked, these 5 year old students caught on very quickly and could use any of the programs with ease and without any more explanation. Seeing a device like the iPod and iPad used for such educational purposes, rather than for entertainment purposes, really demonstrated the many benefits technology is playing and will continue to play in early elementary classrooms. There were moments when frustration would set in from the students when something was not working and had a glitch, but there are always downsides to technology. Using the technology at the appropriate times in a student's learning is also something we realized was very important to understand.

As mentioned in our research instances above, the programs we were using are designed and only become beneficial for students who have an initial understanding of the concepts we researched. Manipulatives are still a very useful tool to use in the classroom, and they should still be used. Our research was to see when, and to what extent, to use technology, as well as how useful it is when teaching number sense skills. With the way young children are now using technology on a daily basis, they are becoming more familiar with learning and doing more with computers, iPods, and even iPads than ever before. Schools are using these tools more often as well, so such tools simply add to the mix of ways for students to learn. As researchers, we identified whether a student's ability level allowed for them to use a more hands-on approach with manipulatives in order to provide more direct assistance. Once we assessed that the students had a base of understanding of a particular concept, we chose a program focusing on the corresponding skill, and provided the students with either an iPod or iPad in order for them to improve their number sense skills while using this technology.

As we reflect on our research and our collective data from our kindergarteners, we wonder what the future has to hold in regards to number sense and how children will continue to learn to master these concepts. After a couple of times working with the kindergarteners, we immediately realized how hard it is to come up with various activities and manipulatives to use for students based on their individual strengths and weaknesses. The process of gathering, setting up, and cleaning up manipulatives is also very time consuming, so when we recently received the iPad as a new tool to use, we realized how technology allows you to differentiate and meet the needs of various learners. Recently, there has been a lot of publicity and articles about technology in the classroom and how schools are trying to incorporate technology in the classrooms to aid in student achievement. Many districts have used grant money towards iPads as a differentiated and engaging tool for student learning. Many schools believe the iPad can provide specific assistance without the teacher having to facilitate every lesson and review. After working with the iPad for a couple months, we instantly saw the difference in not only how eager students were about getting chosen to come learn, but also in the thought process that was occurring during learning. Overall, we hope to see more use of the iPad as we become future educators because we have discovered the iPad's ability to contain various options for each software program, in order for the teacher to select the most appropriate options based on the needs of all of our students.

Works Cited

Jordan, N., Kaplan, D., Olah, N., & Locuniak, M. (2006). "Number Sense Growth in Kindergarten: A Longitudinal Investigation of Children at Risk for Mathematics Difficulties." *Child Development*. Vol. 77, 1: p.153-175.

Kim, S., & Chang M. (2010). "Does Computer Use Promote the Mathematical Proficiency of ELL Students?" *J. Educational Computing Research*. Vol. 42, 3: p.285-305.

Lago, R.M. & De Perna, J.C. (2010). Number Sense in Kindergarten: A Factor-Analytic Study of the Construct. School Psychology Review, 39, 164-180.

Rasanen, P., Saliminen, J., Wilson, A.J., Aunio, P., & Dehaene, S. (2009). Computer-assisted Intervention for Children with Low Numeracy Skills. Cognitive Development, 24, 450-72.

Richardson, K. (2002). *Assessing math concepts*. Bellingham, WA: Math Perspectives.

Smaldino, S., Lowther, D., & Russell, J. (2012). *Instructional Technology and Media for Learning: Instructor's Copy*. Tenth Ed. Boston, MA: Pearson Education, Inc.

Van De Walle, J. (1990). *Elementary school mathematics: Teaching developmentally*. White Plains, NY: Longman.

Van De Walle, J.A., Karp, K., & Bay-Williams, J.M. (2010). *Elementary and Middle School Mathematics: Teaching Developmentally*. Boston: Allyn & Bacon.

Weiss, I., Kramarski, B., & Talis, S. "Effects of multimedia environments on kindergarten children's mathematical achievements and style of learning." *Educational Media International* 43.1 (2006): 3-17.