Developing Subitizing Skills in Kindergarten

The number sense research began in Mrs. Berni Carmack’s kindergarten classroom. A schedule was set up for data collection with the students every Tuesday and Thursday from 8:00-10:30am for twenty weeks. This allowed for a half hour planning period before the students arrived at school. Mrs. Carmack selected the students that were involved within the research. Throughout the research period, Mrs. Carmack also assigned instruction preferences based on mathematical assessments and curriculum. Each researcher received seven kindergarten students. From observation, it became apparent that the students would experience the most benefits when attention was focused solely on them. A schedule was designed where each student received approximately fifteen minutes each day for one-on-one instruction throughout the week. Each session, various iPad applications were incorporated into the lessons associated with the curriculum and mathematical assessments. Through this one-on-one work with the students, questions and “wonderings” about the kindergarteners’ development of number sense began to form.

Children go through a process of counting that enhances future subitizing skills. Rote counting occurs when students can accurately count in sequence without the use of visual support. The act of rote counting can allow for better subitizing because the students already have a basic understanding of the numbers and what they mean. For example, a kindergarten student who has developed rote counting skills understands that five is more than four and will be better able to recognize that when it comes time to practice subitizing. As children develop and begin to make sense of what numbers mean, they interact with shortened counting. Shortened counting occurs when counting is not needed. Simply glancing at an arrangement of objects in a familiar pattern provides the student with enough knowledge to recognize the correct numerical symbol that represents the total number of objects within the familiar pattern (Van de Rijt et al. 2009). When shortened counting becomes apparent in students’ mathematical practices, the student is likely to be successful with subitizing tasks.

There are four basic processes in the development of early mathematics: executive functions, fluid language, subitizing, and language. Shifting is an important skill that is evident in subitizing procedures. Shifting requires the student to complete a subitizing task with a different strategy. This can be seen within the study when the students completed the subitizing task in two different ways: the dice method and the story problem method. Subitizing can be accounted for in these activities based on student responses. Students who were able to subitize looked at die pattern and immediately stated the corresponding numeral. In the story problems, students were provided with a set of counters and only had to count them once in order to divide the counters into different ways of representing the original number of counters. Students who were able to subitize in the story problems also did not have to recount the counters within each group when separating the original pile of counters into how they “saw” the original number of counters.

Several interesting research questions based off of individual instruction with the students began to formulate. A research breakthrough came through observation of Mrs. Carmack’s daily math lesson. She drew a die on the board with the five dot pattern to represent the numerical symbol five. She then asked the class to draw how they “saw” five: whether it was 1+1+1+1+1, 2+3, or 2+2+1 to list some examples. The research incorporated this concept with the students during individual instruction to see how they reacted. Almost every student either saw the number a different way or had a different process of showing how he or she recognized the number (i.e. drawing, tiles, verbal explanation). As research progressed, the students were participating with instruction based on more detailed and complex tasks based on the die patterns. The students were asked to “make” numbers in different ways previously mentioned while the researchers incorporate the use of ten frames. A ten frame is a rectangle that has two columns and five rows. Ten frames are useful in mathematical instruction to provide students with a visual example for seeing the number ten as one unit of ten instead of ten individual squares. After several weeks of working with the students, one question became prominent
throughout the research process. Do students’ abilities with recognizing number patterns impact number sense development?

Through research and literature reviews, information were found that provided insight to the current work with the students and inspiration to further the progress with the students. Douglas Clements (1999) in *Subitizing: What is it? Why teach it?* provided the biggest breakthrough in the research by giving a term to the research being conducted with the students: subitizing. According to Clements (1999), subitizing is the act of “instantly seeing how many”. This related to the activities being completed with the students where they would roll the die or dice and tell how many they saw the given number represented on the die or dice. For many of the students, they were able to immediately recognize the number for one die but struggled when rolling two dice. Clements (1999) discusses that there are two ways to subitize: perceptually and conceptually. According to Clements (1999), perceptual subitizing is the simple recognition of a number whereas perceptual subitizing is more advanced and requires the students to “organize number patterns as composite parts and as a whole”. Robinson makes the claim that children are surrounded by groups of objects from a very young age and that they develop stable mental images of spatial arrangements that they can eventually reconstruct for themselves. This, along with constant exposure to number names used to describe arrangements helps children form pattern-name associations. The type of subitizing where students work with dice is known as perceptual subitizing. Perceptual subitizing is an important basis for further learning of numbers and the development of number sense. By organizing dots into recognizable subgroups, the ability to recognize and give number names to groupings is facilitated; joining and separating visual patterns provides a basis for developing part-whole number relationships.

The research focused on conceptual subitizing skills with the students due to the work with dice and pattern recognition. For example: a die with four dots can be seen as “4”, two sets of 2, or four individual dots. Spatial patterns, according to Clements (1999), is just one kind of pattern and conceptual subitizing can be done through finger, rhythmic, and spatial-auditory patterns. Another example of conceptual subitizing that is common in kindergarten is to say, “I knew there were 4 more so eight, nine, ten, eleven” while counting on fingers. The research with the students focused on their ability to conceptually subitize. Students were asked to explain how they saw a number on the die/dice through drawing, grouping objects, or verbally communicating their thought process. As our research progressed, the students were presented with a story problem. The story problem incorporated a different approach to the dice method, requiring the students to sort through excess information within the story problem to complete the task at hand. The students were provided with a random number of counter pieces to represent people that wanted to ride a sled. Some people had to wait, while some could ride the sled. The students were asked to create as many combinations of the original number as possible, showing us the patterns with the counters. When working with the iPads, the students were also working on the skill of how they see a number with the application entitled “Hungry Fish”. This application provides the students with a given number inside the fish. Bubbles then appear on the screen and the students are instructed to combine bubbles together in order to add up to the number inside of the fish.

Clements (1999) continues to discuss factors that can make it difficult for students to subitize and develop subitizing skills. Clements (1999) claims that the actual arrangements can make it difficult for students to recognize pattern sets and the set must lend itself to grouping. Otherwise, the student will struggle. This was extremely helpful because a couple of students in the research did not seem to grasp the concept of subitizing and constantly needed support in order to complete the activities. For example, if the pattern was seen as “random” to the student or the student could not see a group within the pattern, it would be difficult for the students to subitize. Clements (1999) makes the claim that kindergarten students may have not yet developed the skills necessary to create patterns in a comprehensive format in order to subitize. This claim was something that the researchers made sure to consider when working with students. When frustration appeared when the students did not seem to “get” the pattern, one consideration was that maybe the pattern seemed random to the student or that
he or she was developmentally unable to create and recognize patterns. Clements (1999) concludes that subitizing is a skill that can be developed through activities and practice, but ultimately it is something that the students need to come to on their own.

Lynda Wiest (2006) makes a similar claim to Clements, stating that age and skill development associated with number relationships lends itself to subitizing easier and with greater success. Wiest (2006) recognized that subitizing become a relatively unconscious process with practice and time spent on this skill; subitizing becomes an unconscious effort of simply recognizing a given number within a pattern based on recognizing the pattern or creating groups in a manner to recognize the number being represented in a personal meaning. Throughout the research with the students, subitizing practice was incorporated each time when working with the students in order to allow for the act of subitizing to potentially becoming a natural process. Research and instruction incorporated a die/dice, whiteboards, counters, and verbal retellings of groupings and number patterns. A majority of the students used the dry erase board and counters. Interestingly, those that used visuals did not always have a structured approach to grouping. Some students simply grouped with any numbers that popped into their head while others grouped in an organized fashion, starting with zero or one and increasing to reach the number provided. Those that used the dry-erase board incorporated a familiar shape to represent their groups of a given number. Research found that the students also had an easier time completing the subitizing task and creating patterns when the problem was presented without the use of dice. Students who typically struggled with the dice and counter patterns were able to comprehend the question and perform the activity quicker and with more accuracy than when they worked with the dice. This concept of using dice and struggling with dice is something that Rosemary Robinson (1979) discussed in Dots: Dice and Dominoes. Robinson (1979) discusses the understanding of number present in children and some kindergarten students recognized that all numbers can be conceptualized as being composed of various combinations of other numbers. This can lead to the recognition of number patterns. The development of the skill that allows children to visualize arrangements of small numbers of objects can provide a basis for enhancing children’s knowledge of number relations (Robinson, 1979).

Robinson (1979) defines subitizing as the process of instantaneously recognizing the number of items in a spatial arrangement without counting, very similar to the definition provided by Clements (1999). Robinson and Clements both make an interesting claim that subitizing is a precursor to rote counting. Robinson (1979) claims that children are surrounded by groups of objects from a very young age and that they develop stable mental images of spatial arrangements that they can eventually reconstruct for themselves. Clements (1999) claims that subitizing is more “basic” than counting because subitizing is possible directly through interactions with the environment. He supports his claim by stating that he found students who could subitize sets of one or two but could not count them and that the reverse of this is not true, that he had not encountered a student who was able to count a set of numbers and not subitize. Through the number sense research, it has been found that both of these claims to be untrue. Students need to have a basic understanding of numbers that is developed through rote counting. It has been discovered that subitizing is a skill that many students in kindergarten need to develop whereas all of the students within the research have the ability to count to at least twelve. As a result, the researchers believe that rather than subitizing being a more “basic” skill than counting, counting is indeed necessary in order to subitize. Clements (1999) presents counterarguments to his initial claim that subitizing is a precursor to counting by stating that children develop subitizing later in their educational career as a shortcut to counting and that subitizing is a form of “rapid counting”. This is similar to what was encountered when working with the students. Every student within the research who can subitize is a very strong counter, but the students who struggle with counting cannot subitize well.

In one research encounter, a student who was able to complete both subitizing tasks was unable to recognize simple patterns representing the numbers four and five. Based on our research, this student may not have mastered some of the patterns of numbers, but has mastered the dice pattern. For example, a student may be able to look at a four represented on the dice (two columns each with two dots) and immediately recognize it as four but if the pattern was rearranged to create four
dots in a diagonal line across the dice the student may need to count the dots, or even recognize that as three because they are familiar with three being a diagonal line. Some students also need to count the dice each and every time, but are able to create a variety of ways of grouping the given number. This suggest that the student may understand that a number can be representing in more than one way, but does not have the pattern recognition component mastered yet.

Research found that the students had an easier time completing the subitizing task when it was presenting in a word problem format without the use of dice. This was determined because it took students less time to comprehend what was being asked and performed the activity correctly. The researchers were also able to use larger numbers when working with a word problem rather than the dice. The students were also clearly able to come up with various groups of numbers that can be added together to accurately represent the original number. However, certain word problems presented within a story format do not have the same results when measuring subitizing skills. When students were provided with a subitizing task in a story format related to the personal lives of the student and researcher, the total number of groups or ways the students can “see” the original number is much lower than other story problem formats. The personal story problem asked the student to count the total number of counter chips in front of him or her. The researcher would then inform the student that the counter chips represent cookies. The student and researcher can each receive some of the cookies. The student was then asked to create as many groups as he or she could think of to represent different ways of dividing the original number of counters between the two people. The students were stuck on the fact that both people had to receive an even number of counter chips, even when the researcher informed the students that this did not have to be the case. This information has provided the researchers with the knowledge that the wording of a story problem and incorporating the task on a personal level may lead to inconclusive results. It was also found that students who had a strong understanding of patterns and ten frames were able to come up with more groups for a given number in either dice or story problem scenario.

In regards to the literature, there is a direct correlation between subitizing and the development of different math skills. Clements (1999) concludes his article stating that subitizing is a fundamental skill that ultimately lends itself to the student’s better understanding of a number. This was found through the work with the students. Students who have developed the ability to subitize can also recognize full ten frames and are better equipped to determine what “makes a number”. It has also been found that students who are struggling with rote counting and very basic number recognition also struggled with subitizing tasks.

When beginning this research process, it was unknown that the tasks decided to work on with the students had a term. By discovering the term “subitize”, the researchers were able to expand concept and find many available resources.

Through the work with the kindergarteners, researchers recognized the relationship between basic number sense and subitizing as well as the relationship between subitizing and future math concepts. One of the exciting discoveries during the time with the kindergarteners dealt with the link between subitizing and the ability to recognize a full ten frame as the number ten without counting each individual dot. It was discovered, after working with the students on these skills for several weeks, that the students who thrived when working with the dice and recognizing numbers in dot patterns also succeeded in recognizing a full ten frame as the number ten. Researchers were able to recognize through the work with the students that there is a link between the two skill sets. Because of this apparent link, it was possible to partner up with the cooperating advisor and develop an iPad application to further the development of this connection. The application allows students to see a domino depicting numbers 1-18 and create a ten frame two different colors to represent what they see on the domino. This has allowed observations to become apparent to see if the students create similar patterns that they see in the domino or if they create a different pattern that makes more sense to them based on the learning environment and personal experiences.

The work with the kindergarteners has provided a lot of time to build on the knowledge concerning subitizing and what that means in regards to number sense for a child. The researchers
were also able to come up with many different ways to incorporate the development of subitizing in a child through games and activities. While the dice served as a starting point, it became possible to move past and into a variety of iPad games, whiteboard work, and using different manipulatives. The research findings conclude that subitizing is a very integral part of the developing number sense.
Works Cited


Robinson, R. (1979). Dots: Dice and Dominoes. Mathematics Teaching,