10-28-2011

Alternative Ways of Developing and Assessing Fluency with Basic Facts

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Alternative Ways of
Developing and Assessing Fluency
with Basic Addition Facts

Amy Young
Senior Honors College Thesis
October 28, 2011
Introduction

After completing most of the requirements for a minor in Elementary/Middle School mathematics from Western Michigan University, it became clear that I wanted to pursue a research study involving elementary mathematics for my Senior Honors College Thesis. The focus of my research was alternative ways of developing and assessing fluency with basic addition facts with a focus group of first grade students who had not yet mastered their basic addition facts. My interest in this topic came from various readings and videos shown to me in my MATH 3520 methods course at WMU. The focus was not to teach children a procedure for solving math problems, but to develop a greater number sense to lead to increased fluency with mathematics.

As a future elementary school teacher, my job will be to help my students succeed in every subject. Many times students find mathematics frustrating and dismiss any interest in mathematics after timed tests or other stressful situations lead them to believe that they are not good at math. I felt it was necessary to gain a better understanding about different methods to teach young children to avoid the common frustrations that previous methods of teaching basic skills brought to students.

After finding a topic that interested me, I approached my professor, Mrs. Gina Garza-Kling, to be my thesis mentor, as she seemed to have a great background in mathematics education, specifically in the area of teaching for fluency and conceptual understanding of mathematics. She agreed to help me in this great learning experience, and together we designed a research study to answer the question: after receiving small-group instruction on conceptual, meaningful ways to solve basic math fact problems involving combinations of ten and making
ten strategies, do students have a better understanding of the meaning of mathematics and rely less on counting to determine answers to basic facts?

We identified a possible school to work with, St. Augustine Cathedral School, in Kalamazoo, Michigan. Two first grade teachers at the school identified a possible population of students to work with based on their current knowledge of basic addition facts. These students were struggling with their basic addition facts and relying heavily on counting to solve problems. After an initial round of interview assessments, I divided the students into two groups and then met with each group three times. Following these meetings, which I have labeled mini-lessons, the students were given a post assessment again in the form of an interview. Overall I saw an improvement in the students’ post assessment scores and the students showed less reliance on counting and greater fluency with basic addition facts. In the following sections, I will describe the readings that informed my work, the methodology of my study, and the results of my study in detail.
Literature Review

In traditional mathematics classrooms, students attempt to learn basic arithmetic facts without really understanding why they were completing the steps they learned through rote memorization. Common methods for teaching basic facts include timed tests, worksheets, and flash cards, which have been shown to increase student anxiety when doing math problems (Baroody, 2006, 24). These activities have proven to be unsuccessful in helping children improve in their mathematics fluency. “...[M]any students, even in middle school, still rely on counting as a primary method of adding” (Wheatley and Reynolds, 1999, 9). Although appropriate for young children, beyond the early grades counting becomes an inefficient and inferior method for solving math problems. Conceptual methods of instruction help children understand the meaning behind the mathematics, leading to a better understanding and increased proficiency with basic facts. “The National Research Council concluded that attaining computational fluency – the efficient, appropriate, and flexible application of single-digit and multidigit calculation skills – is an essential aspect of mathematical proficiency” (Baroody, 2006, 22).

The knowledge about the benefits of conceptual mathematics lessons is not new. A 1978 study conducted by C. Thornton showed a positive correlation between high achievement scores on addition facts tests administered to young primary school children and the use of a conceptual approach when teaching basic facts. Some of the most common strategies used by children include: “counting on, using doubles, thinking one more or one less than a known fact, using 10 and the commutative property” (Thornton, 1978, 214). The students in the experimental group showed more mature strategies for finding addition sums and scored nearly twice as high as their peers in the control group who were taught using traditional methods. The results of the experiment showed, in every category, the experimental group who received the instruction
through use of strategies outperformed the control group. Thornton further noted that children who were explicitly taught or encouraged to use certain strategies often adopted these strategies to use during later examination of basic facts. This research suggests that there must be a deliberate focus on facilitating discussion around the strategies children use when solving basic mathematics problems.

Students considered fluent in basic math facts will have a variety of strategies to use when they encounter a problem they do not automatically know the answer to. Students are ready to develop and examine strategies as early as kindergarten or first grade— they only need a few facts memorized before they can use those memorized facts along with strategies to solve other, harder, basic facts. For example, once children have learned their doubles and combinations of ten, they can apply doubles plus/minus one or making ten strategies to derive answers to facts such as 8+7 or 9+4, respectively. In essence, strategies are a way for the student to use a “clue” to figure out the answer (Kling, 2011, 84).

Reluctance to teaching children to learn basic facts through the use of strategy may stem from the idea that this type of instruction will take longer and need more of the teacher’s time in order to be successful. A 1981 follow up of the Thornton study by researchers Carnine and Stein focused on teaching strategies to young children to help them learn easier facts. The researchers introduced the children to related facts and had them repeat the facts, utilizing the idea that a number plus one is the next number in the sequence (6+1=7). In the first study, the children in the treatment group performed twice as well as the students in the rote memorization group. These children required 74 minutes of instruction as opposed to the control group’s 50 minutes of instruction. A second study showed that the children in the treatment group, even under the same time limit of instruction, performed better than their peers in the control group. The second
group of experimental students did not perform quite as well as the first (a mean of 13.2 as opposed to the group one mean of 13.9), but the difference is nearly insignificant. This study suggests that even though the students required more time, they were able to learn more facts overall, have a greater level of accuracy and retain the facts much more than their peers (Carnine and Stein, 1981). Thus the extra time spent initially was well worth it in the long run.

In their book, *Beyond Arithmetic*, Mokros, Russell, and Enconomopoulos describe the importance of students really understanding what is going on in mathematics, rather than worrying about how quickly they can solve a math problem. A child’s lack of good memory should not keep the child from being a good mathematician, as long as that child becomes fluent in different ways to solve math problems (Morkos, Russell, and Economopoulos, 1995). These mathematics educators do not promote the use of timed math tests because speedy recollection of facts does not tell the teacher what the child understands about math. A student proficient in mathematics may suffer from timed test anxiety, and perform much worse than he or she normally would if not under the pressure of a “Mad Minute” or other form of timed test (Morkos, Russell, and Economopoulos, 1995).

As states adopt the Common Core State Standards (2010), it is important for teachers to take note of changes in curriculum expectations. The Common Core State Standards suggest a need for teachers to redefine their goals for teaching basic facts. In first grade, students are expected to “Add and subtract within 20, demonstrate fluency for addition and subtraction within 10, and use strategies such as counting on; making ten; decomposing a number leading to a ten; using the relationship between addition and subtraction and creating equivalent but easier or known sums,” (CCSS, 2010). There is no emphasis placed on instant recall of basic fact answers or rote memorization, instead the focus is on fluency and strategy application.
In 2008, V. Henry and R. Brown conducted a study to test the use of derived-fact strategies in conjunction with retrieval from long-term memory as opposed to the use of retrieval (memorization) alone. The students using the more sophisticated derived-fact strategies showed a stronger correlation with number sense proficiency than did their peers using memorization alone. One indication of fluency in mathematics is when students are able to explain a strategy used to solve basic addition facts problem and do not solely rely on recall. In the Henry and Brown study, students explained their strategies for solving a set of addition problems during one-on-one interviews and small group sessions. Evidence in the Henry and Brown study indicated that successful arithmetic skills are often stemmed from many techniques, not relying on counting, memorization, or the use of strategies alone. For example, a student who is taught basic math problems simply through memorization might have a weaker strategic competence than a student who was taught with some conceptual understanding. The student who was taught through memorization as well as a conceptual approach could show a higher competence and greater adaptive reasoning (Henry and Brown, 2008).

A child must memorize some basic facts in order to use strategies to derive other answers using strategies. For example, a child faced with the problem 8+5 must first recognize that breaking the 5 in to 2+3 will allow him or her to add 2 to the 8 (Making a 10) and then adding the remaining 3 to obtain an answer of 13. The child had to have the basic facts 2+3 = 5 and 8+2 = 10 memorized in order to use this strategy successfully. Yet this memorization can occur in conceptually meaningful ways. The Henry and Brown study suggested that emphasizing basic facts acquisition using strategies could help students develop a base-10 understanding of numbers rather than focusing on memorizing a great number of isolated basic facts. If the students learn to compose or decompose numbers using 5 or 10 or any combination
on a base-10 understanding, their fluency with numbers will increase allowing them to regroup numbers and use strategies when faced with a problem whose answer they do not know.

In the Henry and Brown study, the researchers used three types of data collection to obtain results. These methods included: teacher surveys, addition and subtraction basic facts pretests, and one-on-one assessment interview forms. I used this study’s protocol to create my research methodology, which will be discussed in the next section.
Methodology

The purpose of this research was to design a project that would allow me to examine how young children think about mathematics, explore different ways to help develop basic addition fact fluency with the children, and consider different ways to assess what the children have learned about mathematics. This stemmed from the following research question: After receiving small-group instruction on conceptual, meaningful ways to solve basic math fact problems involving combinations of ten and making ten strategies, do students have a better understanding of the meaning of mathematics and rely less on counting to determine answers to basic facts?

To begin my research, two teachers at St. Augustine Cathedral School identified students in their first grade classrooms who had not yet mastered many of their basic facts as the end of the school year approached. Each student was given a number 1-8 to protect his or her identity. These students were then given a pre-interview assessment which consisted of 10 questions, and which I administered with the assistance of Mrs. Garza-Kling. Seven of the questions were basic one-digit addition problems and three of the problems were word problems. A sample of the pre-assessment is included in the appendix. During the interviews I prompted the students to answer questions about how he/she solved individual problems. I chose this type of assessment in an attempt to minimize the students’ anxiety over taking a math test and as a way to find out more about how the students were thinking. I was less concerned with whether or not the student got the correct answer and more concerned with how they were getting their answer. I utilized the 2008 Henry and Brown study when planning my research, but changed a few things. I utilized addition basic facts pre-interviews as a way to gain information about how the students were initially solving the problems and used a post-examination to determine how their approaches to solving basic addition fact problems changed after the a series of three mini-lessons, which
involved different approaches to teaching students the strategy of “Making 10.” The activities in these lessons involved the use of quick images, Ten Frames, and Tens Go Fish. During each session, the students also discussed why it is important to use strategies to solve math problems they do not automatically know the answer to as well as practiced making combinations of 10. The interviews of the students were recorded on a tape recorder so I could listen more closely to what they were thinking at a later time. The results of these pre-assessments were scored based on the correctness of the answer as well as the method the student used to solve the problems. When a student used a counting technique, the response was coded with an “A.” When a student reported using some sort of strategy to solve the problem (such as doubles plus one, etc.), the response was coded with a “B.” When a student reported “just knowing” an answer (memorization), the response was coded a “C.” If the student reported guessing at an answer, the response was coded “D.” Some students chose not to answer certain problems, and their answers were recorded as “No Answer” or “NA” and were included with the incorrect answers. The student responses were coded and organized in the table (see sample below). Correct answers were coded in yellow and red indicated the answer was incorrect. If a student answered “No Answer,” although considered incorrect, the box was colored blue for clarification. The following table is an example of the coding system. A full table of all eight students’ responses is included in the results section.

<table>
<thead>
<tr>
<th>Student Number</th>
<th>Assessment Question</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td>A</td>
<td></td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>NA</td>
<td>A</td>
<td>A</td>
<td>A</td>
</tr>
</tbody>
</table>

Following the pre-assessments, the students were placed into two groups of four students each based on how well they answered the questions on the pre-assessment or the sophistication
of their solutions. I am using the term sophistication to describe how they answered the question. A student who relied solely on counting shows a lower level of sophistication in solving the problems, whereas a student who utilizes strategies to solve the problems shows a higher level of sophistication. Group one consisted of students who scored lower in comparison to their peers or used a lower level of sophistication on all or most answers. Group two students scored higher in comparison with their peers or used a greater level of sophistication when solving the problems on all or most of the problems. I then met with the students for three mini-lessons, which consisted of three thirty-minute lessons for each group of students and which were all tape-recorded. Hand written notes from the three mini-lessons are included in the appendix.

The first lesson consisted of familiarizing the students with combinations of 10. The students were prompted to explain some combinations of 10 with which they had become familiar. In group one, the students were eager to share ideas about combinations of 10. They struggled a little bit at first, and they were not sure of all the combinations of 10. We reviewed the use of a Ten Frame, which one student reported they had used at the beginning of the year “almost every day.” The Ten Frame consists of a five unit by two unit grid. The following is an example of a Ten Frame. In this study, a double Ten Frame was also used, which consists of two side-by-side Ten Frames for a total of twenty total spaces.
To represent different numbers on the Ten Frames, the students were given counting chips, similar to poker chips, to place in the spaces. We began by representing 8 on the Ten Frame and discussed how numbers can be decomposed and manipulated in different ways. In group two, we went through the same process of talking about combinations of 10 and manipulated numbers on the Ten Frame. In both groups, I introduced the Making Tens strategy to the students, named it, and we practiced it. The strategy was introduced by using the double Ten Frame and moving chips from one Ten Frame to the other to make one of the Ten Frames completely full. By the end of the first session, the students were still counting, but each student could show me how to make 10 in an addition problem, even if it was not their first instinct to use the Making Tens strategy. The students experimented with the Ten Frame to solve the problems 8+5, 9+6 and 4+7, all of which would be suitable Making Tens strategy problems. The following is a representation of the problem 8+5 demonstrated on a double Ten Frame.
The black chips represent the number 8. The green chips represent the number 5. To utilize the Making Tens strategy, the student will move two chips from the 5 green chips over to the Ten Frame with the 8 black chips.

The student can now clearly see after making a full Ten Frame, the answer to the problem 8+5 is 13.

The second day of mini-lessons included more work with Ten Frames, combinations of 10, and a game called Tens Go Fish (Investigations in Number, Data, and Space, 1998). Tens Go Fish encourages children to make combinations of 10 which become what would be “matches” in regular Go Fish. For example, if a student has a 3, he or she would ask his or her partner “Do you have a 7?” If they are able to make a combination of 10, they can put that combination down, as one would put down a pair of cards in Go Fish. There are many benefits of meaningful practice of combinations of 10 such as this. The children gain a better understanding of how to compose and decompose numbers and become more fluent with groups of basic facts, such as combinations of ten that we’d like to see students memorize (Kling, 2011). As mentioned earlier, students can’t utilize other addition strategies without first memorizing some basic facts. I began
the lesson by reminding the students of the name of our strategy and why we use the strategy. I decided to help the students “warm up” through the use of quick images with Ten Frames, which involves the use of a Ten Frame by placing some chips on the Ten Frame, which was covered away from them, and then giving them a couple of seconds to look at it. They then had to write down the number of chips on the paper. I did this to try to help the students move beyond counting to see the numbers in different ways (subitizing) and to look for patterns. I paired the students with classmates that they were sitting by and they proceeded to play a few rounds of Tens Go Fish. In group one, Student #1 had to think very hard about what card to ask her partner for when playing Tens Go Fish. She also struggled with the commutative property and struggled when she had a small number and needed to ask for a 7 or 8. The commutative property is the mathematical property that means adding two numbers “a” and “b” together, a+b=c, is the same as adding b+a=c. Also in group one, Student #5 continually asked for a 3 when he had an 8, rather than asking for a 2. I addressed this incorrect pairing by having the student utilize a Ten Frame and move the chips to make a complete Ten Frame of ten, wherein the student saw that the actual pairing was supposed to be 8 and 2. All of the students eventually caught on to the game. In group two, the students seemed to have a better grasp on the combinations of 10 because it took less time to begin playing the game with partners and their fluency with the combinations of ten seemed greater than that of group one early on. This can probably be attributed to the fact that group two students performed better in comparison on the pretest and already had some increased sophistication when solving problems. Overall the students seemed to really enjoy playing Tens Go Fish.

My goal in the third and final lesson was to get the students comfortable using the Making Tens strategy to solve basic addition fact problems. I asked the question: “Why is it a
good idea to use the Making Tens strategy?” The students responded by saying the Making Tens strategy is a good idea because you can use it to solve problems more quickly and “better.” The students said it is easy to make ten and each group of ten is ten, you don’t need to count (when using a Ten Frame.) They also commented that breaking down numbers (decomposing) makes it easier because you work with small numbers. The students practiced with Ten Frames and practiced making tens with the problems 8+3, 7+6, and 8+7. The problems 7+6 and 8+7 could probably be more naturally solved with a doubles plus one strategy, but there is no reason a child could not choose to use the Making Tens strategy instead. In group two, one student chose to use the doubles plus one strategy and explained her method of solving 7+6 by adding 6+6 and then adding 1 to make 13. As a warm up, the students listed combinations of ten and each student was responsible for naming a different combination of 10. Student #5, in group one, was able to list the combination 8+2 as a combination of 10, when previously he thought 8+3 was equal to 10. This could have been due to the extra practice in composing 10 in the previous lesson, through the use of Tens Go Fish. The students began seeing numbers on their Ten Frames in collections, rather than counting each chip when representing numbers. Students who think in collections have greater fluency in mathematics because they are able to approach both familiar and unfamiliar mathematics problems with increased flexibility (Wheatley and Reynolds, 1999, 9). By collections, I mean for example seeing 3+3=6 rather than counting 1-2-3-4-5-6. They were seeing numbers in groups rather than just as single units. Because they had extra time in their lesson, group two played a second game of Tens Go Fish with different partners than the previous lesson. To give the students a better idea of how they were manipulating numbers, I labeled what they were doing as composing or decomposing numbers.
After completing the mini-lessons, the students were given a post-examination. The post-examination was the same as the pre-examination and was administered again in an interview fashion. The answers are coded in the same way, and the results of the post-examination are detailed in the results section.

**Results and Conclusions**

The following tables represent the students’ performance in the pre-assessment and post-assessment interviews (note: assessment questions are given in Appendix A):

<table>
<thead>
<tr>
<th>PRE</th>
<th>Assessment Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Number</td>
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</tr>
<tr>
<td>1</td>
<td>A</td>
</tr>
<tr>
<td>2</td>
<td>A</td>
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<td>3</td>
<td>A</td>
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<td>A</td>
</tr>
<tr>
<td>6</td>
<td>A</td>
</tr>
<tr>
<td>7</td>
<td>C</td>
</tr>
<tr>
<td>8</td>
<td>A</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>POST</th>
<th>Assessment Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>Student Number</td>
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</tr>
<tr>
<td>1</td>
<td>A</td>
</tr>
<tr>
<td>2</td>
<td>C</td>
</tr>
<tr>
<td>3</td>
<td>A</td>
</tr>
<tr>
<td>4</td>
<td>A</td>
</tr>
<tr>
<td>5</td>
<td>C</td>
</tr>
<tr>
<td>6</td>
<td>C</td>
</tr>
<tr>
<td>7</td>
<td>C</td>
</tr>
<tr>
<td>8</td>
<td>A</td>
</tr>
</tbody>
</table>

Table Key: A - counting, B – strategy, C - memorization, D- guess, NA – no answer, Red – incorrect answer, Yellow – correct answer, Blue – no answer (incorrect)
The students placed in Group One were 1, 4, 5, and 7 and Group Two included students 2, 3, 6 and 8. The following is a comparison between each individual student’s pre-assessment and post-assessment. The key is the same as the above tables. The pre-assessment is listed first, followed by the post-assessment. The percentage scores represent the percent of problems the student answered correctly.

<table>
<thead>
<tr>
<th>Student Number</th>
<th>Assessment Questions</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>A A A A A A A A A</td>
<td>10%</td>
</tr>
<tr>
<td></td>
<td>A A A A A A A A A</td>
<td>80%</td>
</tr>
<tr>
<td>2</td>
<td>A A A A C A A A A A</td>
<td>80%</td>
</tr>
<tr>
<td></td>
<td>C B B A C A A A A A</td>
<td>100%</td>
</tr>
<tr>
<td>3</td>
<td>A A A NA D D D A A D</td>
<td>30%</td>
</tr>
<tr>
<td></td>
<td>A C A A C C A B D A</td>
<td>70%</td>
</tr>
<tr>
<td>4</td>
<td>A A A A A A A A A A</td>
<td>90%</td>
</tr>
<tr>
<td></td>
<td>A A C A A A A A A A</td>
<td>70%</td>
</tr>
<tr>
<td>5</td>
<td>A C A C C A A A A NA</td>
<td>80%</td>
</tr>
<tr>
<td></td>
<td>C A A C A A A A D</td>
<td>70%</td>
</tr>
<tr>
<td>6</td>
<td>A A B A C A B A A A</td>
<td>90%</td>
</tr>
<tr>
<td></td>
<td>C B A A C A B A A D</td>
<td>90%</td>
</tr>
<tr>
<td>7</td>
<td>C A C A A C A A A A</td>
<td>60%</td>
</tr>
<tr>
<td></td>
<td>C A C A C A A A A A</td>
<td>50%</td>
</tr>
<tr>
<td>8</td>
<td>A B A A C B A A A A</td>
<td>90%</td>
</tr>
<tr>
<td></td>
<td>A B B D B A A A A A</td>
<td>70%</td>
</tr>
</tbody>
</table>
Table Key: A - counting, B – strategy, C - memorization, D- guessNA – no answer, Red – incorrect answer, Yellow – correct answer, Blue – no answer (incorrect)

After analyzing the results of the post-assessment and comparing them to the pre-assessment, my mentor and I found the following correlations amongst the data:

**Increased use of combinations of ten and making ten strategies**

- In the first question, 6+4, the percent of correct answers in which students reported “instant recall” as their method for answering the question increased from 0% to 50%. This finding is interesting when comparing the results of this study to that of the Henry and Brown 2008 study, where students were least likely to answer the problem 6+4 correctly. This finding may indicate that the methods used in this study could be effective for helping students learn combinations of ten.

- In the second problem, 8+3, the percent of students using a Making 10 strategy increased from 13% to 38%. Another student changed his or her method from counting to instant recall on this question. This is significant because 8+3 is a great example of a problem where the “making 10” strategy would be ideal. The student could decompose the 3 into 2 and 1, and after giving the 2 to the 8 to make 10, easily see that 10+1 = 11.

- Some observations from the mini-lessons indicated all the students knew some combinations of ten, with many of the students able to list all possible combinations of ten. Warm-up from session three had each student share a combination of ten that they remembered without repeating a combination that their classmate had just shared. All of the students did so successfully and quickly, with some giving two combinations. This information was gathered from the students in the session after
they played Tens Go Fish. This finding shows a great improvement because in the beginning of the study, the students had a hard time listing the combinations of ten, whereas by the end of the study this activity became very easy for them.

**Increased willingness to attempt the tasks**

On the pre-examination, three instances of “no answer” occurred, where as zero instances of “no answer” occurred on the post-examination. I believe this finding is significant because it shows a possible decrease of anxiety amongst the students. One of the reasons I chose to use interviews as a form of assessment was to decrease the anxiety students face when taking a math test, especially a timed math test. Having the students answer every question shows they were at least comfortable enough with the mathematics to attempt an answer for every question.

**Increased sophistication in strategies and accuracy**

- At the end of the study, the students indicated more of a “collections” approach to numbers of objects, as they reported seeing “3 dots” instead of “1-2-3 dots.” This finding came from observations in the mini-lessons. In the final lesson, the students were indicating numbers in their Ten Frames by looking at the collection of chips and indicating a number, rather than counting individual chips. This is an important finding because it shows the students are becoming more flexible in their thinking about mathematics and, as indicated by Wheatley and Reynolds, would be able to solve unfamiliar math problems more easily due to their increased ability to recognize and manipulate numbers.

- The students in the study scored a cumulative 53/80 questions correct on the pre-examination and a cumulative 60/80 questions correct on the post-examination. This
finding was important because it showed the students as a whole group improved in terms of correctness on the post-assessment. This finding is important because it shows that teaching in this way, utilizing a more conceptual approach to basic fact addition, may benefit the whole group of students and thus is an effective way to teach basic addition facts.

- Overall, 7 out of 8 or approximately 88% of the students, moved from counting to either strategy use or recall on at least one problem. The remaining student who exclusively used counting in the post-assessment went from 10% to 80% accuracy. This finding is significant because it shows that the students increased in their sophistication in answering basic addition fact problems. The student who still used only counting increased her ability to correctly count, which may indicate an increase in number sense.

- An increase in the sophistication of the students’ strategies was seen on the post-assessment. On the post-assessment, the students answered 8% fewer questions using counting (60 questions as opposed to 55 questions.) The number of questions answered from the use of a strategy increased by 100%, from 4 to 8 questions as a group. The number of questions answered from memorized recall increased by 44%. The number of questions answered in a guess stayed the same. The number of questions not answered decreased from 3 to 0.

Overall I believe this research study was beneficial to the eight students I worked with at Saint Augustine Cathedral School due to changes the students made in accuracy of responses and the sophistication of their answers on the post-assessment. In future research, I would like to examine how the students would respond to another strategy, such as doubles plus or minus one.
It would be interesting to see changes in student performance from a larger sample as well, or across classrooms.

Part of my research question was “…do students have a better understanding of the meaning of mathematics and rely less on counting to determine answers to basic facts?” I believe these students do have a better understanding of the meaning of mathematics and their answers in the post-assessment do show less reliance on counting. I chose this type of assessment (interview) because I wanted to see if the students would show less anxiety when taking a mathematics test. As far as I could tell, the students did not seem intimidated by the assessment at all. They appeared calm and did not seem to get frustrated. I think the students enjoyed being able to talk about the way they were thinking about the math problems. I made sure to tell the students that I was less concerned with whether or not their answers were correct and was more concerned with how they were thinking about the problems. This seemed to put the student at ease and I was able to get a really good understanding of how they were thinking about the problems. In many timed test situations, the students can get discouraged and the effect on the students’ feelings about math are often adverse (National Research Council, 2001, 193). I believe a more effective assessment and use of both the teacher’s and students’ time is to use interviews as a form of assessment. The teacher gains a better understanding about how the student is thinking and the pressure is taken off of the student and he or she has a chance to talk about why they think their answer is correct.
References


Appendix
Appendix A

Basic Addition Facts Questions Pre/Post-Assessment

1. 6+4
2. 3+8
3. 9+4
4. 8+5
5. 9+9
6. 5+9
7. 7+8

Word Problems

1. There were 6 children on the playground. Nine more children came out to play. How many children were on the playground then?
2. Maria has 7 dollars. She wants to buy a book that costs 11 dollars. How much more money does she need?
3. Pete has 14 pencils. Six of his pencils are red, and the rest are blue. How many pencils does Pete have?
## Appendix B

### Session Notes

**Session 1**

<table>
<thead>
<tr>
<th>Student 1</th>
<th>Student 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>At end of session saw perhaps some movement towards making 10</td>
<td>good at using 10's frame</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Student 3</th>
<th>Student 5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>4 + 6</td>
</tr>
<tr>
<td></td>
<td>still counted</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Student 4</th>
<th>Student 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>good at composing 10</td>
<td>6 + 4</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Student 7</th>
<th>Student 8</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5 + 5</td>
</tr>
<tr>
<td></td>
<td>made 10 in 10’s frame by herself</td>
</tr>
<tr>
<td></td>
<td>easily makes 10</td>
</tr>
</tbody>
</table>

Overall, everyone could show me how to make 10 in an addition problem.
Session Notes
Session 2

<table>
<thead>
<tr>
<th>Student 1</th>
<th>Student 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Is really thinking during 10s to recall combinations. Still counting to try to make 10 when given. Still struggles when smaller number is first.</td>
<td>Good w/ combinations of 10.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Student 3</th>
<th>Student 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acting very silly. I can't tell if he understands the game. He has answered combinations of 10, he knows combinations of 10.</td>
<td>Confused on $8 + _ = 10$, has repeatedly said 3.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Student 4</th>
<th>Student 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good w/ combinations of 10 associative property.</td>
<td>Caught on very fast to game. Knows combinations of 10.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Student 7</th>
<th>Student 8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Took a minute to understand game but got it eventually.</td>
<td>Noticed empty spaces in 10s frame. Knows combinations of 10.</td>
</tr>
</tbody>
</table>
Session Notes

Session 3

Observational notes showed every student could name some combination to 10 in warm up made 10 and then counted up.

Student 1

\[
\begin{align*}
6 &+ 4 \\
&= 10 \\
&= 7 + 3
\end{align*}
\]

- counted chips when they were represented as 8 + 7 in 10s frame

Student 2

\[
\begin{align*}
5 &+ 5 \\
&= 10 + 0
\end{align*}
\]

decomposed 10 into 8 + 2

- counted chips on 10s frame to solve 8 + 3
- represents 5s on 10s very strangely.

Student 3

\[
\begin{align*}
4 &+ 6 \\
&= 10
\end{align*}
\]

could not tell me the making 10 strategy

Student 4

\[
\begin{align*}
3 &+ 4 \\
&= 8
\end{align*}
\]

decomposed 10 into 9 + 1

- solved 8 + 7 using making 10

- explained commutative

Student 5

\[
\begin{align*}
3 &+ 7 \\
&= 8 + 2
\end{align*}
\]

good at manipulating numbers

Student 6

\[
\begin{align*}
6 &+ 4 \\
&= 10
\end{align*}
\]

can explain steps of 10 frame

- solving 8 + 7 using making 10

- 6 and 5 worked together to make 10s instead of competing

Student 7

\[
\begin{align*}
2 &+ 3 \\
&= 5
\end{align*}
\]

counted in head to solve 10 + 3

Student 8

\[
\begin{align*}
10 &+ 0 \\
&= 9 + 1
\end{align*}
\]

- they really like 10s Go Fish

- move 3 to 7 to make 10, add 10 + 1 = 11

More of a collection approach by 3rd session saw 3 instead of 1, 2, 3 Group 2 got to all were playing 10s Go Fish successful.