# A Constructivist Approach to Technology Based Problem Solving

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## Abstract

This research was designed to determine if the integration of a SMART Board in a collaborative setting will promote mathematical understanding of problem solving and motivate students to become critical thinkers. The purpose of this research is to create a constructivist based learning environment for 7th grade math students that will address this question. Progression graphs, created with data from SuccessMaker data, will identify the speed of advancement before and during the integration of the SMART Board interactive whiteboard. It is expected that the SMART Board, combined with a constructivist approach to learning, will increase the rate at which the students progress in their understanding of mathematical problem solving. This will be due in large part of the ability to collaborate with their peers, review their work with a more critical eye and make the concepts relevant to their lives. The scores in the assessment software and Georgia's annual Criterion Referenced Competency Test (CRCT) will allow us to compare the rate of change of the testing group to the control group.

## Research strategy

There are two 7th grade math classes in this rural, low income (Title 1), school located in North Georgia. Both teachers planned collaboratively and taught the same lessons. I utilized the SMART Board interactive whiteboard as one of the tools in my classroom while the other teacher did not. She kept with the traditional style of teaching throughout the year. While we used the same textbook and projects, she used the overhead projector and I used more technology. Her class was the control of this research

by not using the advanced technology. The school year runs from early August to the end of May.

Both of us had three ability grouped classes for 90 minutes each day. There was one higher-level, one mid-level and one lower-level math class for each teacher. A note needs to be made about the two higher level classes: The other teacher had an "Advanced" class that was comprised of all gifted students that were expected to complete the 7th grade math curriculum by the end of the first semester. They then proceeded to the 8th grade curriculum for the remainder of the year. I had an "Honor's" class that was composed of gifted students as well as others that have proven to be more mathematically inclined according to testing. This class was not projected to work as fast, nor go as far as the Advanced class. We spent two-thirds of the year on the 7th grade math curriculum, and then proceeded to enrich the curriculum and touch on the 8th grade content for the remainder of the year. The enrichment and 8th grade content was achieved after the state standardized testing, the Criterion Referenced Competency Test (CRCT).

The results of the research was assessed in two manners. The first measure of change was with the use of ***SuccessMaker Math***, from Pearson Learning. This software is designed to assess various mathematical understandings and identify the mathematical level of the student. It is designed with a broad view of what a student show know and understand at a specific grade level. The base level of mathematical understanding for each class was assessed with the use of this diagnostic computer software. This software allowed us to track student progress throughout the year. At the beginning of the year, as well periodically throughout the year, each student's level of understanding of mathematical concepts was recorded as indicated by the software and then the class

average was calculated. This progress was identified with the grade level equivalent assigned to the students. Simply stated, if a class is identified as being at a level of 6.3, it means that the grade level equivalent is 6th grade, third month. If a student was not at the school for the entire time of data collection, that student's scores were not included in the data.

The progress of class average was graphed to determine the rate of change in mathematical understanding. The baseline of the assessment were the ending scores for each child from the end of their 6th grade year. New students to the school had an assessment period that included 300 questions that will allowed the software to determine the level of the student. This assessment period was completed by mid-September.

The second measure of results was a comparison and evaluation of the student CRCT scores from 6th grade and 7th grade. Students that did not take this test in the 6th grade were not included in this portion of data analysis. The CRCT is designed to test the students according to the state mandated curriculum, the Georgia Performance Standards (GPS). The CRCT questions are written around the GPS. The GPS and CRCT are designed to teach and assess the application of mathematical concepts.

The first phase of the research involved preparing the students to work collaboratively with their peers to solve presented word problems. This phase also included modeling how to use the SMART Board. At various points, students were able to go to the SMART Board and practice writing on it.

In the second phase, students began their problem solving in small groups at the SMART Board. Their work was recorded and printed for review at the end of the class. Having a hard copy enabled children to self-reflect and see exactly what they did with

their group. This afforded them the opportunity to walk through each of their steps and identify what worked well and what could be changed next time they work through a problem.

The final phase was the longest. All classes utilized the SMART Board interactive whiteboard in their collaboration for problem solving. During this time, I observed and collected data for this research to determine if student collaboration with SMART Board had an impact on student learning.

**Implementation of Research**

In the first phase of the research, I modeled the process of solving problems on the SMART Board with the students' help. I facilitated this process by using higher level questioning to identify needed information. Students used a graphic organizer (Diagram A) to assist them in identifying the needed information found within word problems.

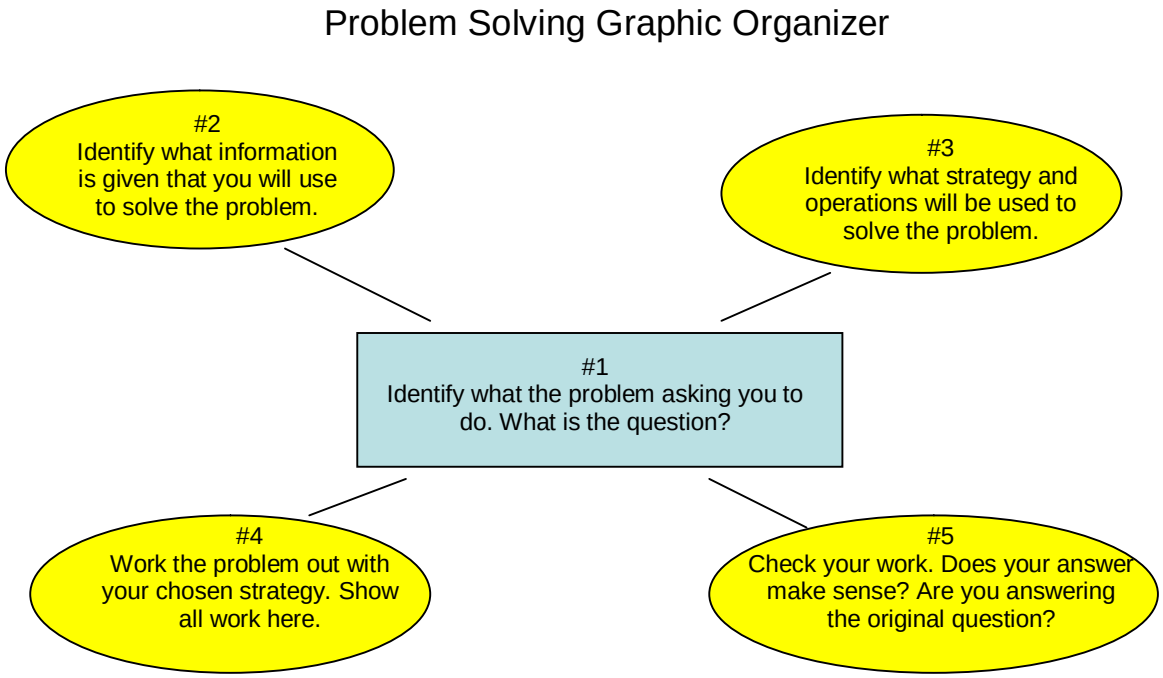


Diagram A

The first phase of the research entailed the first couple of months of school, but it was a continual process within the classes. Of the three classes, the Honor's class picked up the various problem solving strategies very quickly, although they favored certain strategies. This class reluctantly used the graphic organizers, instead preferring to complete the word problems in their own manner.

The lower and middle level classes took longer to effectively learn the various strategies of problem solving. The students in these classes created the graphic organizer as assigned, but they had great difficulty thinking through what they were doing at each step of the process. A portion of this problem appeared to be related to their reading level and the fact that they had difficulty pulling needed information out of the written problem. When they did, they would copy the information word for word instead of paraphrasing for the task of problem solving. This proved to be very cumbersome for many students and also proved to be one of the biggest challenges for me, especially on the SMART Board. Also, most of the students had not yet mastered the process of thinking through the presented problems and determining the best method of solving each problem. Many students had a good understanding of the mathematical concepts, but they had great difficulty determining what concept to use for each problem. To assist with this issue, we discussed the various problem solving strategies, listed them and then taped them to each desk and around the classroom. This was done to be a constant reminder of the various strategies that are available for the different problems. The students were also required to identify which strategy to use for each word problem they solve in step three of the Problem Solving Graphic Organizer.

The initial research design was to start each class on the SMART Board at a different time to assess the impact on learning. As the phases progressed, it was evident that this was not a viable step in the research because it appeared to slow some students down and rush other students. As an educator, I feel it is important to allow the students to progress at a speed in which they are comfortable. Because of this, I assessed the proper point to begin the each class working on the SMART Board with their problem solving.

Due to the difficulty the lower level and middle level classes had for the problem solving processes, more time was required for the first phase, but we began working on the SMART Board in early October. This added to the interest of these students to complete the work as assigned.

Since the higher level class progressed much faster, they began working with the SMART Board in late September. This class did very well working in collaborative groups at their desks and effectively completed the problem solving process when assigned. The successful collaboration transferred to the SMART Board for problem solving, but not without some minor issues. The primary issue was the fact that each student wanted to do the writing on the board and dominate the board. When the students reflected on their problem solving, the lack of cooperation of some students was the number one concern. Some students felt, for the first time, that other students were not working for the group, but instead for themselves.

The students were also initially more concerned with the neatness of the board than the actual process of solving the assigned problem. For this reason, some students would write and then erase their name two or three times before reading the actual

problem. This was also done with any of the work that was written while solving the problems. This waste of time was frustrating for some of the students that wanted to get to the work.

To address the previously mentioned issues, I took all but one of the "markers" off the board and I assigned one person to write the names of the group. I also assigned a leader to each group. The leader was to assure that all students were being fair to the others in the group. By taking the markers off the board, the students were better able to remember that simply holding a marker does not give them the authorization to write. This forced the students to work together more collaboratively. While the students knew that they were able to "write" with their fingers, the rule was made that only the person holding the marker could do the writing. These two simple solutions seemed to help streamline the time at the board.

The students in the other two classes begin using the SMART Board in smaller groups than the first class. This was done to help them get more accustomed to working collaboratively on the board and learning how to better share the time on the board. In the smaller groups, each person was required to actively participate instead of sitting back and letting others do the work. This was especially important for the lower level learners.

## Results

### SuccessMaker Math grade equivalents

All of the students, at all learning levels, enjoyed using the SMART Board, but it appears to be of most benefit to the lower level learners in regard to the SuccessMaker grade equivalent data. While the middle and higher level learners eagerly participated in

class and the small group problem solving, there was not recognizable gain in the learning curve for these classes. The grade equivalents for these classes increased at a steady pace, just as the traditional classrooms' scores increased. It appears to be a progressive increase, at a steady rate for both classroom settings.

At the beginning of the year, the Advanced class had an average level of 8.0 and the Honor's class had an average of 7.1. This was a difference of 9 months. By the end of the year, the Advanced class averaged a level of 8.6 and the Honors class averaged 7.8, giving an increase of six and seven month increase, respectively. These averages are not completely accurate due to the fact that if a student finished Math Concepts II, designed for the $7^{th}$ grade, then the software moves the student to Algebra Concepts. Algebra Concepts does not post the grade equivalents due to the content. Both classes had numerous students in Algebra concepts, so this data is deemed void since we do not have accurate grade level equivalencies. Also, due to the differences of the learning abilities and the different curriculum, I do not feel it is accurate to compare the growth of the learning levels of these students. It is interesting to note though that the students that were tracked progressed at a similar pace. (Diagram B)

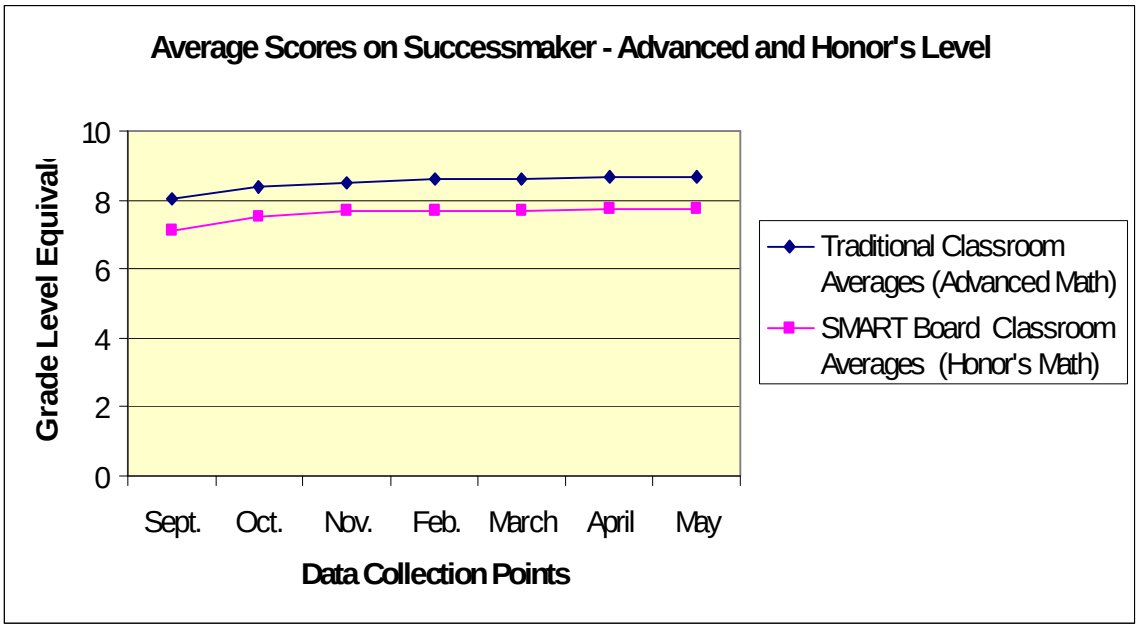


Diagram B

The students in the middle level class began the year in the SMART Board class with an average learner level of 5.6 and the students in the traditional classroom began the year with an average level of 6.3. This was an average of a six month difference between the two classes. By the end of the year, the SMART Board class had an average of 6.2 and the traditional classroom had an average learner level of 6.9. While the students began the year with a six month different in level of mathematical understanding, they ended the year with a difference of seven months, slighting favoring the traditional classroom teaching. This netted a change of grade equivalent average of 6 months for both classrooms within the 10 month period. (Diagram C)

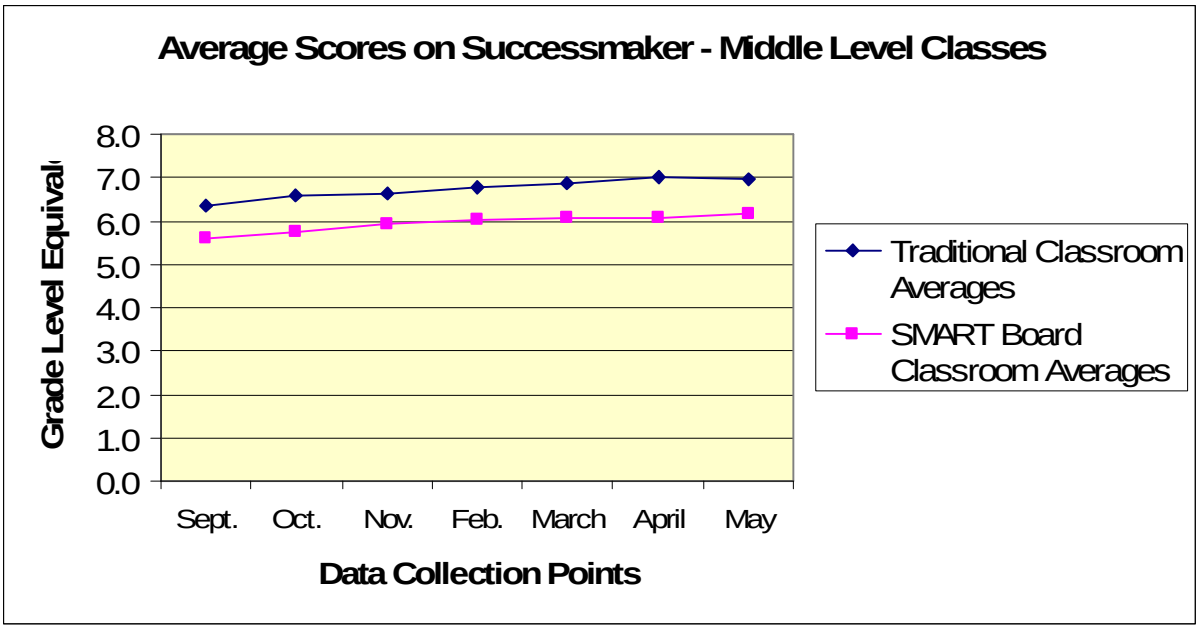


Diagram C

The classes of most interest to this author were the lower level learners. Again, at the beginning of the year, the Traditional classroom of 22 students had a class with a slightly higher average of 5.9 versus 6.7 of the SMART Board class with 15 students. This was a difference of only two months between the two classes with the traditional class in the favored position. A definite change occurred with the SMART Board class shortly after they began using the SMART Board in small groups. By the end of the year, the SMART Board classroom averaged 6.3 while the traditional classroom averaged 6.1, the SMART Board classroom, even with fewer numbers, averaged higher than the traditional classroom at this point. This was a change of a grade equivalent of 2 months for the traditional classroom and 5 months for the SMART Board classroom in a period of 10 months. (Diagram D)

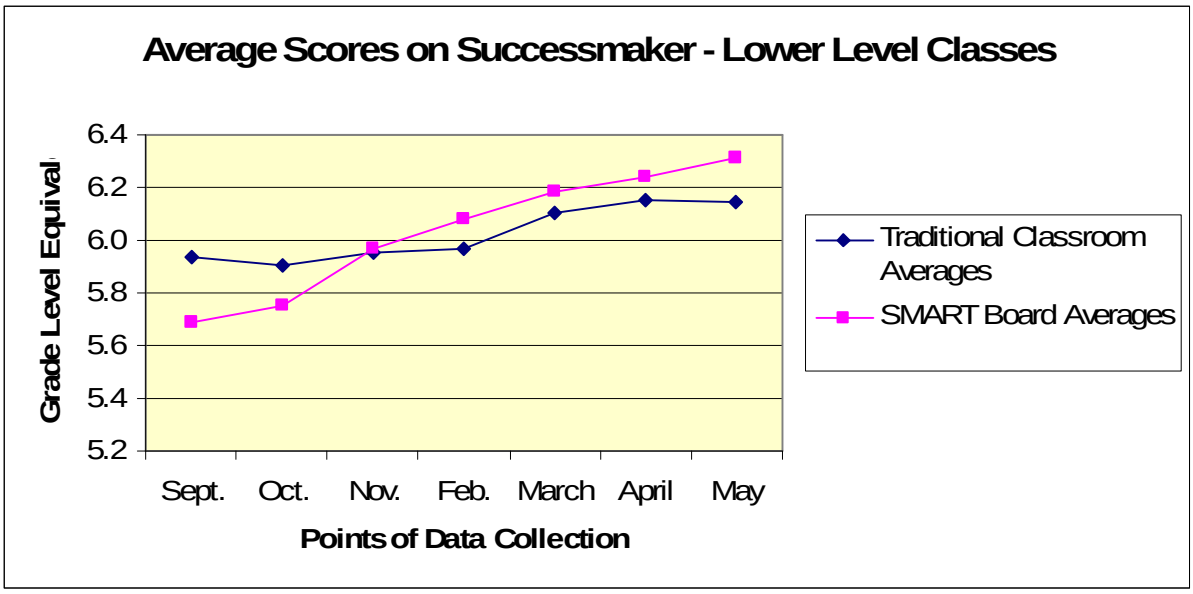


Diagram D

**Criterion-Referenced Competency Test (CRCT) Scores**

Since the Criterion –Referenced Competency Test (CRCT) is designed to gauge what the students have learned in respect to the state standards, this author views the results of this data with a more critical eye. To pass the CRCT, the students must learn the mathematical concepts and how to apply them in a given situation. Problem solving is a prime example of this. For this research, the data from the CRCT's is examined in multiple views. First, we will assess the change in scores from 6th grade to the 7th grade. An individual score of 800 - 849 indicates the student have met the objectives, or expectations, for the year. A score of 850 of above indicates the student has exceeded expectations for the year. Below 800 is an indication that the student has not met the standards for the year. For this study, we will examine the class averages of the scores, not the individual scores, due to the need of confidentiality of student data. Second, we will examine the number of students in each class that increased or decreased their scores

over the two years. Finally, we will view the number of students that did not meet expectations for the year on the CRCT.

As previously mentioned, the high level classes are broken into two sub-groups: Advanced and Honors. The Advanced class was in the traditional classroom setting and the Honor's Math was in the classroom with the SMART Board. The Advanced class had a class average score of 885.8 in 6th grade and an average score of 872.6 in the 7th grade. While all of the students exceeded expectations, this was a decline of 13.2 points. The Honor's class had a 6th grade class average score of 855.4 and a 7th grade class average score of 862.4. In 6th grade, 13 of these students exceeded expectations and in 7th grade, 21 students exceeded expectations, bringing the net change to an increase of 7 points. (Diagram E)

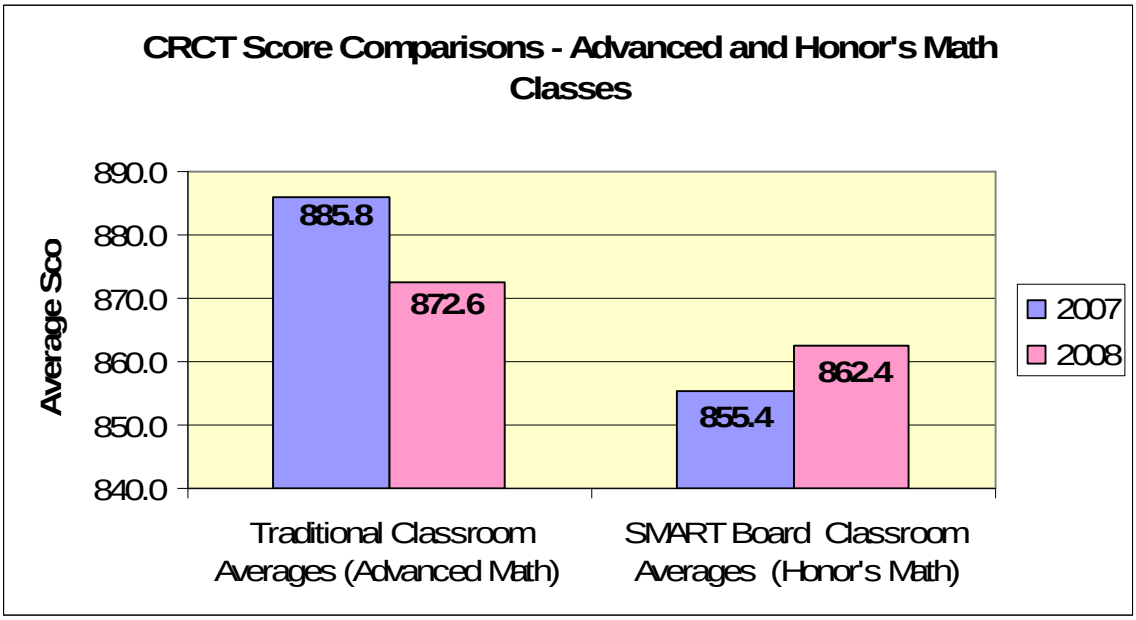


Diagram E

The middle level classes had similar resulting differences in the class averages of CRCT scores. In 2007, the traditional classroom had an average of 891.7. In 2008, the class average decreases 2.1 points to 889.8. The SMART Board classroom had an

average of 815.7 in 2007 and increased it to 820.9 in 2008. This was an increase of 5.2 points. (Diagram F)

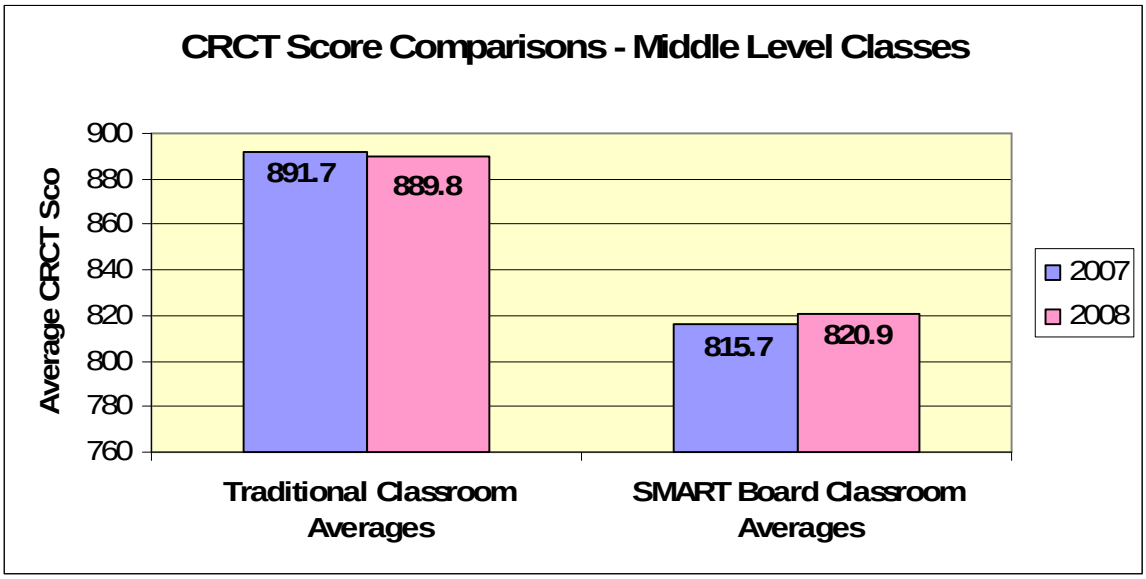


Diagram F

The lower level classes showed the most dramatic change from the 6th grade to the 7th grade years in reference to the CRCT score averages. The traditional classroom had an average score of 798.8 in 6th grade and increased to 801.5 in 7th grade, resulting in a net change of 2.6 points. The SMART Board classroom had an average score of 794.9 in 6th grade and increased the average to 816.7 in 7th grade, resulting in a net change of 21.8 points. (Diagram G)

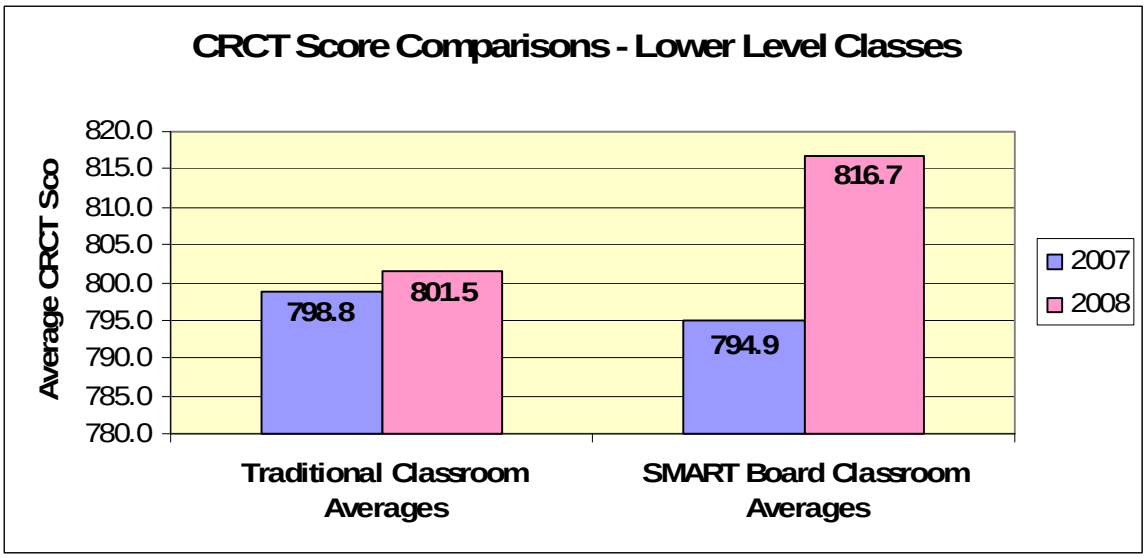


Diagram G

Overall, the SMART Board classroom showed a marked improvement in CRCT scores. This is also pointed out in the review of the number of students increasing their CRCT scores and the number of students not meeting expectations on the CRCT over the two years of testing.

All students in the higher level classes met or exceeded expectations on the CRCT. In the Advanced Math class, seven students increased their scores in comparison to eleven students that had a decrease in scores. In the SMART Board classroom, 20 students showed an increase in their scores and 4 students showed a decrease. No students earned the same score both years. (Diagram H)

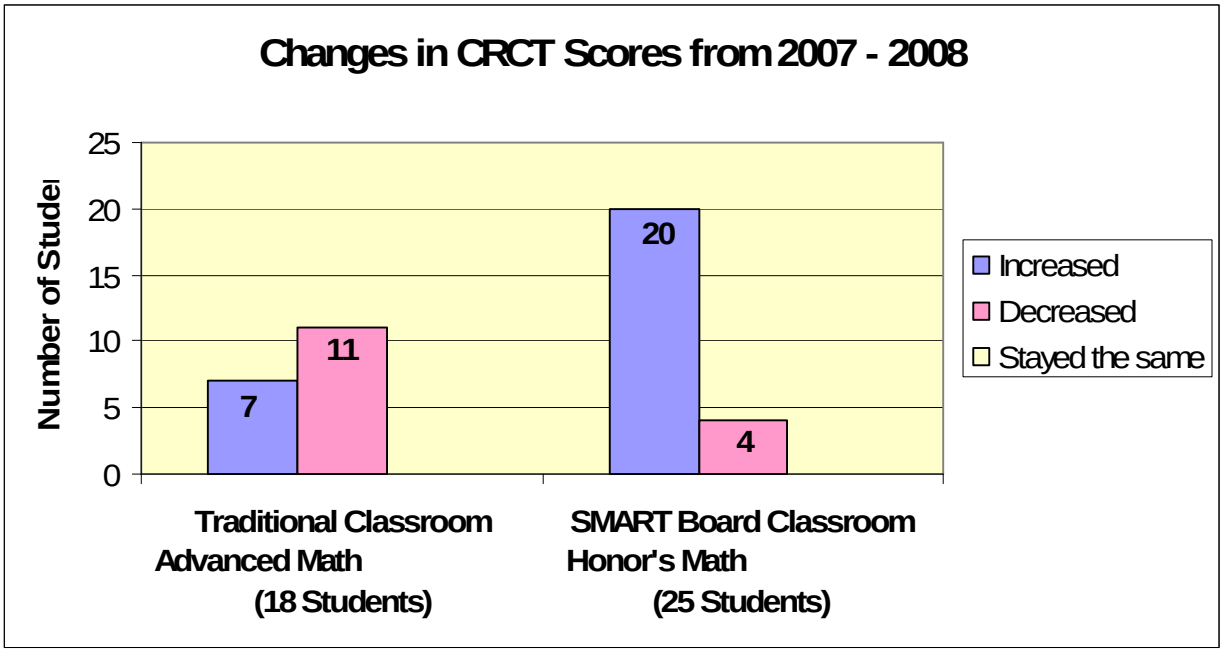


Diagram H

In the Middle Level math classes, the differences were not a dramatic, but still favored the SMART Board classroom setting. In 2007, the traditional classroom had one student that did not meet expectations on the CRCT and the SMART Board classroom had two that did not meet expectations. In 2008, the traditional classroom did not have any students not pass the CRCT and the SmartBoard class had one. This was a change of one student for each classroom. (Diagram I)

The difference in scores between the two years had a slightly different result, again, favoring the SMART Board classroom. The traditional classroom had eight students increase their scores, ten students decrease and one student stayed the same. The SMART Board classroom fared only slightly better with ten students increasing their scores, nine decreasing and none staying the same. (Diagram J)

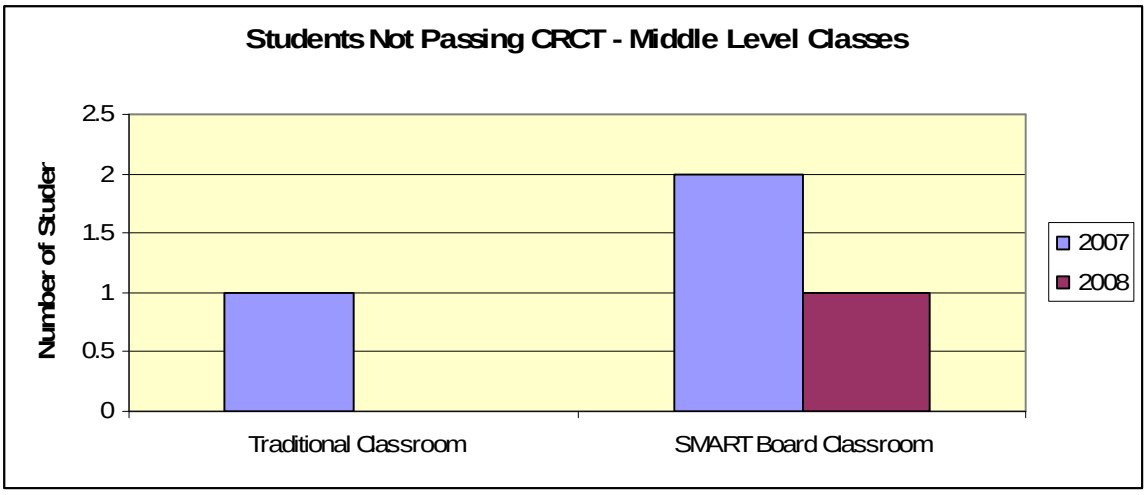


Diagram I

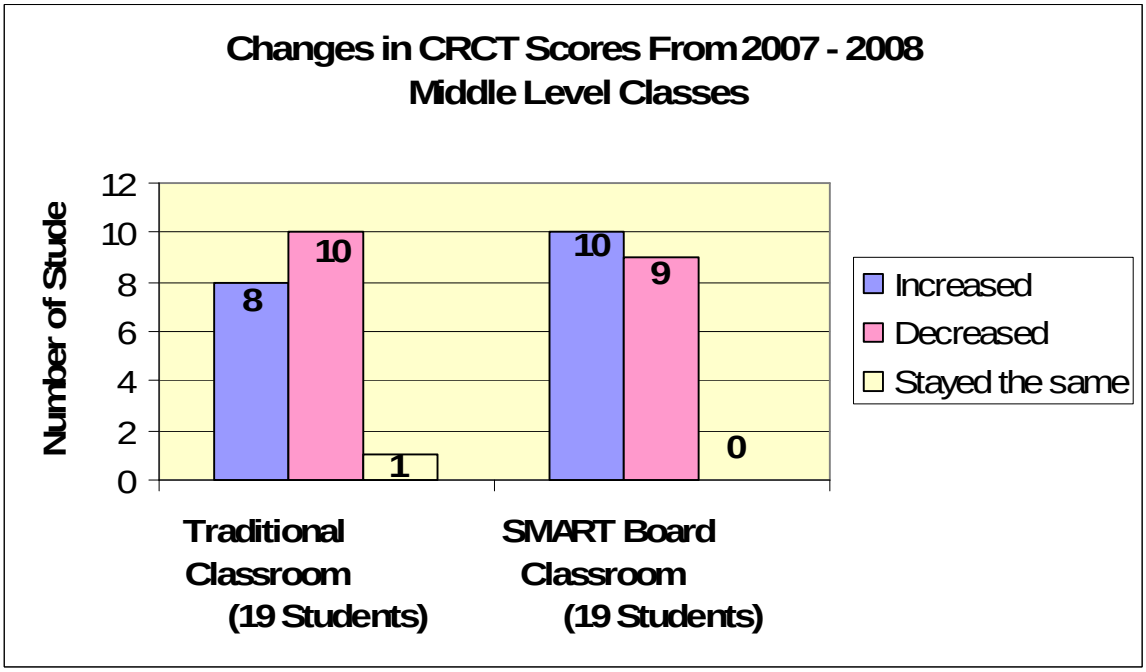


Diagram J

As with all of the other collected data, the lower level class with the SMART Board had the most dramatic difference in the pass rate on the CRCT and the increase in scores. The traditional classroom had eight students that did not pass the CRCT in 6th grade and the SMART Board class had twelve students that did not pass, or meet

expectations. When the scores came in for the 7th grade CRCT, the traditional classroom had eleven students not meet expectations while the SMART Board classroom only had two. (Diagram K)

The change in scores from the two observed years also follows this pattern. In 2008 CRCT, the traditional classroom had eight students increase their scores, ten decrease and one stay the same. In the SMART Board classroom, all of the 15 students increase their scores from the 2007 CRCT. While two students did not meet expectations, they still increased their scores from the prior year. (Diagram L)

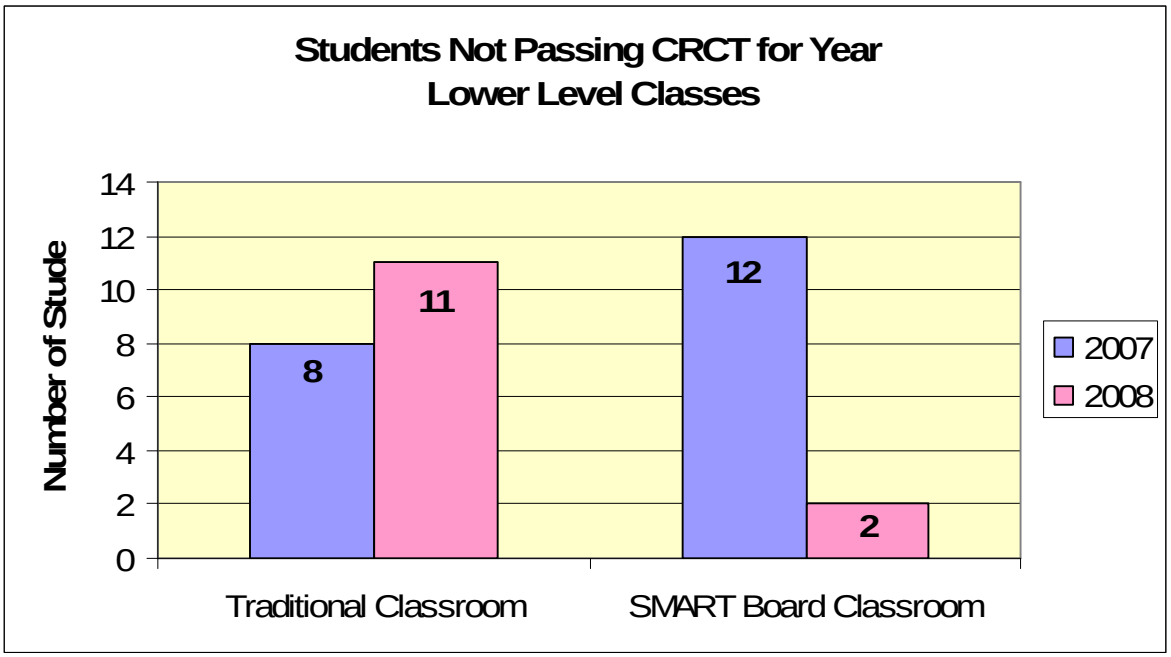


Diagram K

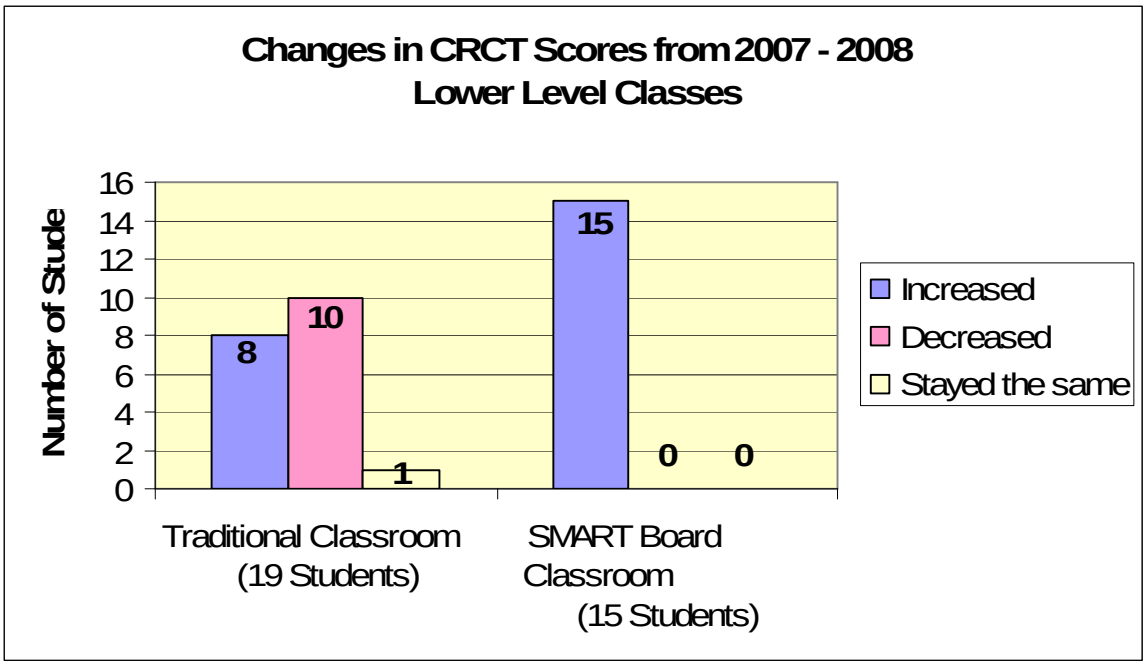


Diagram L

## Analysis

After reviewing the grade equivalency data collected with SuccessMaker, the affects were only seen with the lower level classes. No notable difference was seen in the changes of grade equivalencies with the higher level learners. This analysis does not hold true with the data collected from the standardized testing, the CRCT. The data demonstrates that all of the learners benefited from a collaborative setting with problem solving on the SMART Board. The SMART Board classes showed an increase in overall scores for all classes, while the traditional classroom setting only showed a slight increase in scores for the lower level class. There was not only an increase in overall scores, but also a 18.6% increase in the number of students passing, or meeting expectations, the CRCT for the year. (Diagram M)

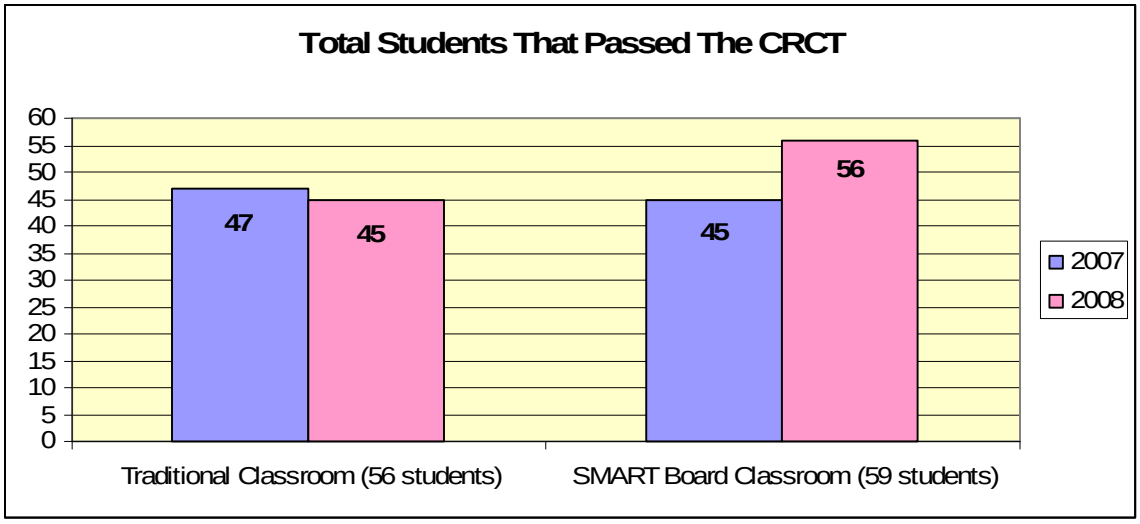


Diagram M

We must also take into account other variables that may have affected the outcome of this study. First, class attendance and discipline issues within the classroom must be addressed. Both teachers follow the school wide plan and are firm with class structure and discipline. Both classrooms had numerous students miss multiple days of class due to suspensions that were either in-school or out-of-school. These suspensions were mainly due to activities outside of the math classroom. These activities need be taken into account because when the child is not in class, they are not able to learn as much as the rest of the class. Also, both classroom settings experienced multiple absences due to illness. These absences and suspensions were not taken into account while collecting or reviewing the data.

We also must take into account the students that were not involved with this study's data. These were students that were not in the school for the entire year or did not take the CRCT in 2007. This would involve the students that moved from outside of the state as well as the students that were home-schooled in 2007. While the data from these students may affect the results, it is believed to be a minimal difference in either

direction. Some of the students that were not included were high level while others were lower level. These students are the reason a reader may question the small number of students in the classes.

Finally, the difference in teaching styles must be taken into account. It is understood that both teachers involved in the research are dedicated educators that have similar teaching styles. Both of us challenge our students to think at a higher level and encourage independent problem solving. To help alleviate any discrepancies in the teaching, we collaborated on a weekly basis to align the curriculum and share ideas.

## Conclusion

Overall, the SMART Board interactive whiteboard appears to increase the interest and understanding of the problem solving process. The CRCT scores increased with all classes and more students passed the test. The passing rate for the SMART Board classes was 95%, up from 76% with the same students in 2007. Students at all learning levels enjoyed working on the SMART Board throughout the year. All of the classes showed an increase in the CRCT scores, but the greatest benefit appears to be with the lower level learners.

A review of all of the data showed a marked increase in learning with the lower level students when allowed to utilize the SMART Board in a collaborative, problem solving setting. Upon reflection, this author cannot help but wonder if these lower level students benefited more from the visual representations and hands-on work environment afforded by the SMART Board more than the other students. Many of these students are very low learners and lean more toward the visual and kinesthetic learning styles. The

SMART Board afforded the ability to immediately bring in a graphic, such as a coordinate grid or geometric shape, to explain a concept or solve a problem. This was done with all classes, but as the year proceeded, it was evident that this class benefited the most from these visual representations.

The pros of using the SMART Board in the classroom were visual representations and manipulating, multiple colors available, saving capabilities, and interactive abilities. Combine these features with the increased interest of the students to solve problems while working with the SMART Board and the benefits are countless. The cons were the need for the students to acclimate to writing on the SMART Board, including not standing in front of the projector, and the need for the students to learn that only one person is able to write on the board at a time. This was the most difficult aspect for the students to learn. While this was difficult for many, it forced the students to listen to each other before proceeding to the next part of the problem. The fact that this slowed the students down, making them think and talk through the process should be considered a positive aspect for the use of the SMART Board in the classroom. The collaboration while working with the SMART Board also encourages the students to listen to each other and work together better as a team.

In conclusion, I believe the SMART Board assists students in working together in the problem solving process, while helping them better understand the particulars of problem solving and the various mathematical concepts. The collaborative environment is very conducive to working with the SMART Board. The SMART Board allows the students a chance to view the concepts in a new manner, discussing the details with their peers and furthering their understanding. It appears that the integration of technology in a

collaborative setting does, in fact, promote mathematical understanding of problem solving and motivate students to become critical thinkers.