Increasing Student Achievement and Motivation in Mathematics Through the Use of Interactive Whiteboards

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Increasing Student Achievement and Motivation in Mathematics Through the Use of Interactive Whiteboards

Abstract
The use of interactive whiteboards in the classroom has been hailed as the means in which an increase in student achievement and motivation can be seen. This study aimed to investigate how teachers can effectively incorporate the interactive whiteboard into the mathematics classroom with the purpose of increasing student achievement and motivation. Three third grade classrooms with varying use of interactive whiteboard technology were utilized in this study. Information on multiplication fluency, the ability to demonstrate the mathematical concepts behind multiplication, student views as seen through survey responses, and end of the unit assessment scores were analyzed. Student achievement and motivation increased as a result of utilizing the interactive whiteboard in a highly interactive, student-directed way. Students in the classroom that utilized the technology in an interactive way performed higher academically and demonstrated more favorable views of math and the interactive whiteboard.

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Increasing Student Achievement and Motivation in Mathematics

Through the Use of Interactive Whiteboards

By

Diane Taylor

Submitted in partial fulfillment of the requirements for the degree
M.S. Mathematics, Science and Technology Education

Supervised by

Dr. Diane Barrett

School of Arts and Sciences
St. John Fisher College

April 2009
Abstract

The use of interactive whiteboards in the classroom has been hailed as the means in which an increase in student achievement and motivation can be seen. This study aimed to investigate how teachers can effectively incorporate the interactive whiteboard into the mathematics classroom with the purpose of increasing student achievement and motivation. Three third grade classrooms with varying use of interactive whiteboard technology were utilized in this study. Information on multiplication fluency, the ability to demonstrate the mathematical concepts behind multiplication, student views as seen through survey responses, and end of the unit assessment scores were analyzed. Student achievement and motivation increased as a result of utilizing the interactive whiteboard in a highly interactive, student-directed way. Students in the classroom that utilized the technology in an interactive way performed higher academically and demonstrated more favorable views of math and the interactive whiteboard.
Dedication

This paper is dedicated to my grandfather, Frank Buscemi. He always wanted more for his family then what he had. He taught me to never settle for less than the best and to always give more than I take. I love you Grandpa and I miss you everyday.
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First I would like to thank my mother, JoAnn Gust. I would never be where I am today if it wasn’t for her love and support. She always believes in me and her faith has made me who I am today. Thank you to my husband, Michael Taylor. He is my best friend and has helped me through some very tough times. He always knows what to say to make me laugh. I would also like to thank my grandmother, Lucy Ann Buscemi. She, along with my grandfather, always wanted the best for me. Her faith in me has helped me to achieve more than I could have on my own. Thank you to Sharon Stein and Michele Jammal for welcoming me into their classrooms and allowing me to utilize their students as subjects for my research. Finally, thank you to Dr. Barrett for her support through the whole writing process.
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Increasing Student Achievement and Motivation in Mathematics

Through the Use of Interactive Whiteboards

Increasing student achievement and motivation, especially in the area of mathematics, has come to the forefront in educational initiatives. The focus on standardized testing at the state and national level as well as the United States’ standing when ranked comparatively with other countries around the world has propelled educational leaders into investigating ways in which to increase student attainment in mathematics. Technology has become a key area in this investigation. More specifically, the use of interactive whiteboards in the classroom is being hailed as the means in which an increase in student achievement and motivation can be seen.

Information and communication technologies are a globalizing phenomenon that is reaching all people, including students (Wood & Ashfield, 2008). Information is reaching students at a lightning fast speed via the Internet and other multimedia resources. Wood and Ashfield (2008) contended that this speed and immediacy creates a time of unprecedented change. The field of education needs to keep up with this change and the technology not only in order to motivate and engage students but also to prepare students for their future in which this technology will be commonplace.

The major benefit seen in interactive whiteboards is the greater interactivity it offers for both teachers and students alike. It has been claimed that this interactivity increases student motivation and enjoyment, which in return increases student attainment (Hall & Higgins, 2005). Interactive whiteboards allow the teacher to incorporate a variety of information and communication technology into the classroom. The interactive whiteboard makes it easy for the teacher to switch between one multimedia
resource to another. Also, students are able to interact with the information they are being presented. Students no longer are passive participants in their learning. They can actively seek knowledge and question information with the interactive whiteboard providing a wealth of resources at their fingertips.

Knight, Pennant, and Piggot (2005) suggested that the use of interactive whiteboards create effective conditions for learning that enhance classroom instruction. Their research also pointed to an increase in student learning and confidence that is fostered by the interactive whiteboard’s ability to revisit previous learning (Knight, Pennant, & Piggot, 2005). Hall and Higgins (2005) believed that a major benefit associated with the use of interactive whiteboards in the classroom is the preservation of the role of the teacher in guiding and monitoring learning while access to and use of multimedia resources is readily available to the whole class.

Current educational theory holds that more interactive forms of whole class teaching will be key in raising mathematical standards and performance (Smith, Hardman, & Higgins, 2006). Interactive teaching allows for high quality dialogue between a teacher and her students. This interactivity is believed to lead to higher levels of academic performance (Smith, Hardman, & Higgins, 2006). The interactive whiteboard is a key component in this theory. The purpose of this research is to discover how effective an interactive whiteboard is in increasing student achievement and motivation specifically in the area of mathematics.
Literature Review

The purpose of this literature review is to analyze the claims that an interactive whiteboard can increase student achievement and motivation. There will be a focus on how to effectively utilize an interactive whiteboard in the classroom. Special attention will be given to specific ways in which to utilize an interactive whiteboard to increase student achievement and motivation in mathematics.

The review of the literature begins with a section on instructional technology and previous research’s findings of the benefits of technology use in the classroom. The literature review will then explore all components of an interactive whiteboard as well as how to utilize it effectively in the classroom and the role interactive whiteboards play in mathematics instruction and attainment.

*Instructional Technology in the Classroom*

Information and communication technology is quickly overtaking the world. These types of technology provide instant access to any information conceivable. There is a great benefit towards utilizing these technologies in the classroom. A recent example is the demotion of Pluto from planet to dwarf planet. Since that discovery, every single science textbook is outdated and holds wrong information. However, within hours online websites were updated and reflected the new theory (Ward, 2008).

The use of multimedia can create a classroom without walls (Hall & Higgins, 2005). Multimedia refers to the integration of multiple forms of media and technology. Schmid (2008) defined multimedia as “the use of computers to present text, graphics, video, animation, and sound in an integrated way” (p. 1553). Real life examples and situations, available through the technology, can be utilized to enhance student learning.
Vygotsky’s theory of education focused on providing students with authentic situations. In this way, multimedia use in the classroom is in line with educational theory (Hall & Higgins, 2005).

The reality is students already utilize information and communication technology outside of the classroom. Web 2.0 refers to the trend in using the Internet as a means of social networking as well as a way in which to gather free and open sources (Ward, 2008). It would be naïve to think students are not utilizing Web 2.0 outside of the classroom. If teachers can learn to incorporate this technology into the classroom, very powerful learning can occur. Ward (2008) very accurately stated that we should make it so kids are begging to go to school. With the incorporation of technology, that can be done.

The interactive whiteboard is one device that could make the integration of technology into the classroom a reality. The interactive whiteboard allows both teachers and students to have instant access to the computer and all it has to offer. Teachers and students can control computer applications directly from the interactive whiteboard (Ward, 2008). Questions that arise in class can be instantly researched utilizing the Internet. Work can be saved to share or revisit at a later time period. Web 2.0 can be readily available for student use in the classroom via the interactive whiteboard.

*Socio-cultural Theories of Learning*

Research on interactive whiteboards centers around the socio-cultural theory of learning. The socio-cultural theory suggested that all human action is mediated by tools (Armstrong, Barnes, Sutherland, Curran, Mills, & Thompson, 2005). In other words, we use tools to interact with the world in which we live. Tools refer to a wide range of
resources such as pens, paper, and computers. Even language and diagrams can be considered tools. Under this theory, an interactive whiteboard is a tool in which we can explore our world.

Socio-cultural theory also states that whenever a person encounters a tool they attach meaning to it. Armstrong et al. (2005) offered the example of a chair. If we are interested in sitting down, we see a chair as a tool for sitting. However, if we are looking to reach the ceiling, we see a chair as a tool for standing. This same theory holds true for instructional technology. If the teacher and students see the interactive whiteboard as a tool to increase interactivity in instruction and learning, it will be used in that way. Conversely, if the teacher and students visualize the interactive whiteboard as merely being a presentational tool, interaction will not occur (Armstrong et al., 2005).

Socio-cultural theory recognizes that both teachers and students come to the classroom with a wealth of knowledge and experiences. The teacher and students are also influenced by local, national, and global factors (Armstrong et al., 2005). Their background also includes previous experiences with technology. Therefore, both teachers and students will apply their previous understanding of technology to the new technology. Unfortunately, this typically means a teacher will utilize an interactive whiteboard in the same way they utilize a non-digital whiteboard (Armstrong et al., 2005).

Socio-cultural theory suggests that teachers should be provided with extensive training as to how to utilize the interactive whiteboard in an interactive way. Teachers should not be expected to automatically recognize all the benefits of the interactive whiteboard and the many ways in which to use it effectively. As stated earlier, teachers
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will use their previous experiences with past technologies to develop an understanding of how to utilize an interactive whiteboard. Therefore, teachers should be able to experience the interactive whiteboard in an interactive way before they are expected to adapt it into their classroom and utilize it to increase interactivity in their classroom. 

**Interactive Whiteboards**

Educational theory has begun to place a vested interest in the utilization of interactive whiteboards in the classroom. Educational leaders view interactive whiteboards as a means to increasing student achievement and motivation. One of the key differences between the use of an interactive whiteboard when compared to a traditional whiteboard or overhead projector is the interactive whiteboard’s ability to retrieve a wide array of digital resources to support student learning (Wood & Ashfield, 2008).

Wood and Ashfield (2008) viewed the interactive whiteboard as likely to become a key resource and huge movement in schools in the near future. The interactive whiteboard allows students to interact with the information they are learning. The interactivity of the lessons and the multisensory nature of the resources are viewed as a great way to support lessons and engage students (Wood & Ashfield, 2008). With the introduction of interactive whiteboards to more and more classrooms across the country and world, the question remains, are interactive whiteboards capable of increasing student achievement and motivation or are they simply an entertaining piece of technology that supports traditional teaching methods?

**The Technology.** An interactive whiteboard is a large, touch-sensitive board. It is connected to a projector as well as a computer (Hall & Higgins, 2005). The projector
displays the image from the computer screen onto the board. The computer can be operated through touching the board. The touch-sensitive screen captures everything written on it in real-time (Schmid, 2008). All writing can be saved to the computer for use at a later time.

According to Schmid (2008) the difference between using a computer with a projector and an interactive whiteboard is the fact that the interactive whiteboard makes the computer invisible. Interacting with the hardware and software takes place with the interactive whiteboard. This enables both the teacher and students to work from the front of the classroom. Interactive whiteboards provide teachers and students with an interactive learning environment (Preston & Mowbray, 2008). Ideas, information, images, animations, audio, or video can all be shared through the interactive whiteboard. Preston and Mowbray (2008) held that learning is much more powerful due to the multimodality that the interactive whiteboard offers. The interactive whiteboard supports the visual-spatial, auditory, and kinaesthetic learning styles (Preston & Mowbray, 2008).

*Context for Use.* Knight, Pennant, and Piggot (2004) hold that there are five basic contexts for using the interactive whiteboard. These contexts include teacher as demonstrator, teacher as modeler, shared, guided, and pupils working independently (Knight, Pennant, & Piggot, 2004).

The teacher as demonstrator is a didactic approach in which the teacher is in control. The teacher leads the class and has full control of the interactive whiteboard. Typically the interactive whiteboard is being used to demonstrate and illustrate (Knight, Pennant, & Piggot, 2004). The teacher as modeler context follows these characteristics as well. The main difference is what is being taught is usually intended for the students
to utilize on the interactive whiteboard independently at a later time. Glover, Miller, 
Averis, and Door (2007) suggested that the effect of these contexts is the students see the 
interactive whiteboard as a novelty in the lesson. Therefore, the interactive whiteboard is 
seen as a means of illustrating rather than developing concepts (Glover et al., 2007).

The shared and guided contexts incorporate structured interplay between teachers 
and students (Knight, Pennant, & Piggot, 2004). The teacher leads a discussion utilizing 
the interactive whiteboard. However, students are invited to participate in the lesson and 
demonstrate understanding through their own use of the interactive whiteboard. In other 
words, students are invited to share their responses on the interactive whiteboard. These 
contexts are considered to be interactive by Glover et al. (2007). The interactive 
whiteboard is being utilized to challenge students. Students are being exposed to a 
variety of stimuli via the interactive whiteboard. Glover et al. (2007) saw these contexts 
as a shift towards interactivity.

In the final context, pupils working independently, students take control of the 
interactive whiteboard (Knight, Pennant, & Piggot, 2004). The students utilize the 
software on their own through the interactive whiteboard. Glover et al. (2007) viewed 
this context as enhanced interactivity. This approach focuses on using technology as an 
integral part of most of the teaching in most lessons (Glover et al., 2007). When teachers 
are operating with enhanced interactivity they are aware of all that the interactive 
whiteboard has to offer and the teachers provide many opportunities for students to 
interact with the hardware and software. Teachers operating at an enhanced interactivity 
level allow students to work individually, in pairs, or in groups on the interactive
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whiteboard. This creates an enhanced, active learning environment (Glover et al., 2007). Teachers should aim to reach this level of interactivity.

Classroom Implementation. The interactive whiteboard provides an effective way to integrate multimedia into the classroom. According to Schmid (2008) it creates a seamless and easy access to multimedia resources. Such resources include CD ROMs, digital videos, audio files, and websites (Schmid, 2008). The literature points to teachers and students valuing interactive whiteboards based on their ability to integrate multimedia resources. Preston and Mowbray (2008) stated that interactive whiteboard users can engage in many educational multimedia activities such as viewing simulations and graphics, capturing text, annotating, drawing, and saving all previous work.

Hall and Higgins (2005) discussed eight potential uses for the interactive whiteboard. These uses include using web-based resources in whole-class teaching, showing video clips to help explain concepts, demonstrating a piece of software, presenting students’ work to the rest of the class, creating digital flipcharts, manipulating text and practicing handwriting, saving notes written on the board for future use, and quick and seamless revision (Hall & Higgins, 2005). Preston and Mowbray (2008) agreed, adding to the supporting literature on these eight potential uses for the interactive whiteboard.

Teachers have noticed a difference in their planning procedures when implementing the interactive whiteboard in their lessons. Specifically, teachers feel that the interactive whiteboard requires them to plan with greater precision than they previously had been (Glover et al., 2007). There are so many resources available to them that planning requires them to pick and choose what resources are best suited for the
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Lesson objectives at hand. Also, planning with greater precision encourages teachers to design activities for the different learning styles (Glover et al., 2007).

Teachers feel they can step away from lessons with a prepared script when utilizing the interactive whiteboard (Glover et al., 2007). According to Glover et al. (2007) the interactive whiteboard prompts teachers to be more free in their teaching and allow student interactions to govern the direction of the lesson. Teachers have noticed that the interactive whiteboard increases the pace of the lesson as well. This leaves more time for learning and less time for behavior issues. Students are on task for a significant portion of the lesson when the interactive whiteboard is being utilized (Glover et al., 2007).

Glover et al. (2007) pointed out that teachers feel much more in control when utilizing the interactive whiteboard because the teacher is able to monitor student progress and integrate assessments into the lessons utilizing the interactive whiteboard software. The interactive whiteboard allows for quick progress checks of all students at any point in a lesson (Glover et al., 2007).

Student Views. The literature points to positive students views of the interactive whiteboard. Students are particularly pleased by the interactive whiteboard’s ability to integrate multimedia into the classroom. Specifically, Hall and Higgins (2005) found that students were intrigued that the interactive whiteboard had the capability of integrating all previous educational technologies and multimedia into one, easy to use board. Students appreciate the multimedia resources that are easily accessed through the interactive whiteboard (Schmid, 2008). Schmid (2008) found students valued the
interactive whiteboard due to its ability to attract their attention with the multimedia resources and engage them throughout the lesson.

Knight, Pennant, and Piggot (2005) contended that students view the interactive whiteboard as user-friendly. The students feel comfortable utilizing the interactive whiteboard because it is a conglomeration of all previous educational technologies. This user-friendly view allows students to be more open to experimenting with the interactive whiteboard as well as utilizing it as an aid in their learning (Knight, Pennant, & Piggot, 2005).

Students are excited about the new capabilities the interactive whiteboard brings to the classroom (Hall & Higgins, 2005). Student responses in Hall & Higgins’ (2005) study indicated that students feel interactive whiteboards make lessons more fun and enjoyable. Schmid (2008) found that students felt the interactive whiteboard helped them to focus more during lessons. This increased focus came from the attractiveness of the interactive whiteboard. Schmid (2008) also found students believed the interactive whiteboard helped them understand lessons better. A student surveyed by Wood and Ashfield (2008) stated that it does not matter if you make a mistake on the interactive whiteboard because you can just undo it. This speaks to the willingness of students to take risks in their learning knowing that errors can easily be erased with the interactive whiteboard.

**Benefits of Interactive Whiteboards.** There are many benefits to utilizing interactive whiteboards in the classroom. The power of the interactive whiteboard lies in its ability to create a positive learning environment (Knight, Pennant, and Piggot, 2005). Merrett and Edwards (2005) found the interactive whiteboard to be a more useful
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resource when compared to a projector or a non-interactive whiteboard. The interactive whiteboard generates class discussions and requires student interaction in a whole class setting. The same quality discussions and interactivity were not seen when students worked independently on computers (Merrett & Edwards, 2005).

Another benefit of the interactive whiteboard is its ability to expand the resources and activities that are available within a lesson (Schweder & Wissick, 2008). As stressed earlier, the multimedia capabilities of the interactive whiteboard are unsurpassed by any other form of educational technology. Through the interactive whiteboard the teacher is able to bring the real world to the students. Teachers are able to show multimedia presentations as well as conduct research as a whole class (Schweder & Wissick, 2008).

The visual resources provided by the interactive whiteboard are huge benefits as well. Merrett and Edwards (2005) found the visual examples displayed during their research to be irreplicable when using a non-digital whiteboard or overhead transparencies. Visual learners in the class are able to benefit immensely from the large screen and high quality images that are displayed (Wood & Ashfield, 2008). In Wood and Ashfield’s (2008) research they discovered that the visual aspects of the interactive whiteboard contributed to a feeling of lively and exciting lessons on both the teacher and the students’ part. Video clips, photographs, animations, and text from numerous sources really enabled students to become engaged in the lesson and in return enhanced their learning (Wood & Ashfield, 2008).

Miller (2004) identified many benefits to utilizing interactive whiteboards finding interactive whiteboards to improve classroom management as well as to improve the amount of time students spent on task. Tanner and Jones (2007) furthered Miller’s
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(2004) contention by stating that the automation, editability, transformability, and feedback allow for substantial interaction to be possible. This, in turn, increases the pace of the lessons and deepens the students’ understanding.

Impact on Achievement. The literature suggests that interactive whiteboards have a positive effect on student achievement. Perhaps the greatest impact is seen through the interactive whiteboard’s ability to recall information from previous lessons. Knight, Pennant, and Piggot (2005) stated that the use of interactive whiteboards allow students to revisit their previous learning. This ability provides memory aids to those students who thrive on layout position and color to recall their learning (Knight, Pennant, & Piggot, 2005). In other words, the ability to link to previous lessons help students create a base of knowledge from which further learning can build and develop.

Students learn best through their dominant senses which include seeing, hearing, and touching (Hall & Higgins, 2005). The interactive whiteboard incorporates all three of these senses. Visual representations and sound are all manipulated through the sense of touch on the interactive whiteboard. The ability to utilize all three senses in their learning has a great impact on the level of student attainment (Hall & Higgins, 2005).

Perhaps the greatest impact on achievement comes from the teacher’s ability to gain insight into the level of student conceptual understanding through utilizing the interactive whiteboard (Preston & Mowbray, 2008). Blanton (2008) contended that the most effective use of the interactive whiteboard is to encourage student discourse. Utilizing the interactive whiteboard in the classroom requires students to construct knowledge, demonstrate their understanding, and discuss this understanding with the teacher and the class as a whole (Blanton, 2008). Preston and Mowbray (2008) supported
this belief by stating that teachers are able to elicit students’ ideas and gain evidence of understanding through the interactive whiteboard.

**Impact on Motivation.** The literature also points to a positive correlation between the use of interactive whiteboards and student motivation. Knight, Pennant, and Piggot (2005) stated that an increase in motivation is one of the key benefits of interactive whiteboard use in the classroom. Wood and Ashfield (2008) found that the large screen and multimedia capabilities of the interactive whiteboard produced an element of fun that in turn increased student motivation. Jones (2004) added to these findings by contending that the use of an interactive whiteboard engages students to a greater extent than whole-class teaching without an interactive whiteboard ever could. Student enjoyment and motivation increased because of this engagement (Jones, 2004).

The interactive whiteboard proves valuable to the classroom teacher because of its ability to draw children in, keep students focused, and help them feel motivated and empowered in their learning (Knight, Pennant, & Piggot, 2005). Preston and Mowbray (2008) suggested the increased enjoyment was related to the ability to physically touch and move objects on the screen. Utilizing the interactive whiteboard in an enhanced interactive way captures students’ imagination (Blanton, 2008).

Merrett and Edwards (2005) discovered that the interactive whiteboard motivated students to be more involved in the lessons. In their research, Merrett and Edwards (2005) found there was always a volunteer to share their ideas with the class during an interactive whiteboard lesson. Over time, this did not change. In other words, the novelty of the interactive whiteboard did not wear off. Because of this increased
Schweder and Wissick (2008) held that student motivation and participation can be increased through the use of interactive games via the interactive whiteboard. Students appreciate being able to physically interact with the interactive whiteboard. This interaction motivates students to be actively involved in the lesson (Smith, Hardman, & Higgins, 2006).

An increase in student self-esteem has also been associated with the use of interactive whiteboards (Knight, Pennant, & Piggot, 2005). Preston and Mowbray (2008) contended that the excitement students demonstrate while operating the interactive whiteboard boosts their self-esteem. This boost in self-esteem is especially seen in the areas of science and technology (Preston & Mowbray, 2008). Their newfound confidence allows students to successfully work independently in their learning.

Smith, Hardman, and Higgins (2006) demonstrated an increase in student participation due to the strong visual and conceptual appeal in the way an interactive whiteboard displays and presents information. When teachers allow students to physically interact with the interactive whiteboard, an increase in student motivation is fostered (Smith, Hardman, & Higgins, 2006). Smith, Hardman, and Higgins (2006) also contended that the greatest advantage of interactive whiteboards lies in the high quality, large visual images that can be displayed. Students are immersed in the multimedia (Smith, Hardman, & Higgins, 2006).

The editing capabilities of interactive whiteboards prove to be a highly motivating factor as well. Specifically, students are not afraid to take chances because of the ease in
which work can be edited (Knight, Pennant, & Piggot, 2005). Students, therefore, feel
more and more comfortable to take risks in the classroom. This comfort level enhances
the learning environment and motivates students to be active participants in their learning
(Knight, Pennant, & Piggot, 2005).

**Pedagogical Changes.** Utilizing interactive whiteboards demands a shift in pedagogy. In order for teachers to effectively utilize interactive whiteboards, their
traditional practices must be put aside. Teachers need to resemble the flexibility that is
offered by the interactive whiteboard (Hall & Higgins, 2005). One of the advantages of
the interactive whiteboard is its ability to allow teachers to instruct from the front of the
classroom. However, the teacher must not assume the traditional lecturing role.
Interactive whiteboards demand teachers to take a collaborative approach with their
students (Hall & Higgins, 2005).

The interactive whiteboard requires teachers to create high-quality materials that
will engage students in the lesson (Ward, 2008). An increase in the pace of lessons is
also present when utilizing an interactive whiteboard. Specifically, teachers should
design short, focused interactive segments that incorporate hands on practical activities
(Preston & Mowbray, 2008). Davison (2004) stated that the interactive whiteboard will
support this conceptual change.

The interactive whiteboard facilitates the teaching of difficult concepts through its
strong visual component (Davison, 2004). Teaching has the potential to be extremely
effective through the use of the interactive whiteboard. Mildenhall, Swan, Northcote, and
Marshall (2008) contended that the interactive whiteboard supports constructivist
teaching. Therefore, in order to effectively utilize the interactive whiteboards, teachers
must teach according to the constructivist theory. Following this theory, the interactive whiteboard combines visual, kinaesthetic, and auditory paths to learning (Mildenhall et al., 2008).

It is the teacher’s responsibility to manage the convergence of digital technology that the interactive whiteboard provides to the classroom (Kent, 2006). However, the interactive whiteboards are designed and created for student use, not teachers (Ward, 2008). The interactive whiteboard has the potential to support interactive learning so long as teachers allow students to utilize it (Mildenhall et al., 2008). Hall and Higgins (2005) believed allowing student autonomy in regards to the interactive whiteboard provided the greatest benefit to the students. Teachers need to be able to grant this autonomy to their students.

Smith, Hardman, and Higgins (2006) argued that the interactive whiteboard is creating a shift in the traditional teacher/student discourse. Through the information and communication technology provided by the interactive whiteboard, both teachers and students alike are searching for information to answer questions. The teacher no longer is the supplier of all knowledge. The teacher and the students share the power and learn by making mistakes together (Smith, Hardman, & Higgins, 2006).

Glover et al. (2007) stated that effective teaching utilizing an interactive whiteboard requires the pedagogy to be directed towards enhanced understanding. Teachers must be receptive to changing their teaching techniques in order to enhance the value of the interactive whiteboard. The teacher and students share the roles of teacher and student with each other. In other words, the students will teach the teacher and the teacher will be the student at times.
Implications. Despite the positive light being placed on interactive whiteboards through the literature, there are several implications that need to be taken into account. Knight, Pennant, and Piggot (2005) found interactive whiteboards to have a positive effect on student levels of engagement. However, their research points to this level of engagement not always being sustained. This was especially true when the learning became more challenging (Knight, Pennant, and Piggot, 2005). Teachers need to be aware of the rigor of each lesson and monitor for student engagement and focus.

Students display a preoccupation with interactive games. While games are an exciting and fun way to get students involved in their learning, teachers must be aware that a balance needs to be reached. Evidence suggests that in certain situations and with the right circumstances multimedia games can have a positive effect on student achievement (Hall & Higgins, 2005). However, the interactive whiteboard should be used for structured and meaningful uses as opposed to unstructured uses for gratification such as games.

Hall and Higgins (2005) asked students to describe what they felt were problems with interactive whiteboards in the classroom. Many of the students placed the need to reorient the interactive whiteboard as highly problematic. Other students identified the issue of not being able to see what is on the interactive whiteboard. Sometimes the interactive whiteboard display was not bright enough or the light would hit it just right to make it difficult to see. Both these issues described by students have to do with the technology itself. Therefore, it is important that technical support be easily available to teachers utilizing an interactive whiteboard (Hall & Higgins, 2005).
Another implication brought forth by Schmid (2008) is that the multimedia aspect of the interactive whiteboard may be too over-stimulating for students. Students may feel overwhelmed by the amount of information presented to them in such a short period of time. Schmid (2008) noted that sometimes the lessons happened too fast and students were not able to fully understand what was being taught. It is important that teachers avoid cognitive overload while encouraging students to interact with the multimedia resources. A balance between stimulation and interaction can lead to information being processed more effectively (Schmid, 2008).

Preston and Mowbray (2008) warned that the purpose of the interactive whiteboard is to facilitate not replace hands-on, real world experiences. Specifically in the area of science, the interactive whiteboard should not replace experiments and other activities. It is important for the teacher to utilize the interactive whiteboard in a way that enhances the learning students achieve through the experiments and activities not in place of (Preston & Mowbray, 2008).

Perhaps the key component in making sure that the interactive whiteboard is utilized effectively in the classroom lies in the teacher. The literature asserts that effective learning occurs when teachers have developed an appreciation for the technology and have been trained in the nature of its interactivity (Glover et al., 2007). Therefore, interactive whiteboards in the classroom requires more than installation. Teachers must be advocates for the technology and knowledgeable in how to integrate it into the curriculum and utilize it in a highly interactive way (Armstrong et al., 2005).

When teachers are not properly trained in the technology and are not provided with the opportunity to experience the technology in an enhanced interactive way, the
technology is incorporated into classroom instruction as a means to automate traditional education (Ozel, Yetkiner, & Capraro, 2008). Using interactive whiteboards in this way will not have an impact on student achievement and motivation. The technology needs to be utilized in a way that diversifies the instruction and centers the learning on the student. Therefore, changes in teaching and learning need to occur in order for interactive whiteboards to prove effective (Glover et al., 2007).

Effectively Utilizing Interactive Whiteboards in the Classroom

Interactive whiteboards have the potential to create huge growth in the areas of student achievement and motivation if used properly. Teachers need to be aware of how to effectively utilize interactive whiteboards in their classroom. This includes knowledge on how to utilize the technology at an enhanced interactive level.

Effective teaching can be defined as discursive and characterized by high quality oral work (Smith, Hardman, & Higgins, 2006). It is interactive, encouraging, and utilizes student contributions. Students are expected to play an active part in their learning. They do this by answering questions, contributing to discussions, and demonstrating their reasoning (Smith, Hardman, & Higgins, 2006). The interactive whiteboard lends itself well to this type of teaching. When utilizing the interactive whiteboard teachers need to consciously provide students with the opportunity to develop their understanding via the technology (Wood & Ashfield, 2008).

Teachers must be aware of the appropriate use of interactive whiteboards as well as the many ways in which to make lessons interactive for students via the interactive whiteboard. Teachers should strive to make content relevant to students by allowing students to take ownership and control over the learning process (Wood & Ashfield,
Teaching with the interactive whiteboard requires more than utilizing multimedia resources. Teachers must creatively incorporate and intertwine various multimedia resources together in a way that best suits the lesson being taught. Therefore, teaching with the interactive whiteboard needs to focus on enhancing the process of learning not the product of learning (Wood & Ashfield, 2008).

A Framework for Appropriate Use of Technology. Ozel, Yetkiner, and Capraro (2008) followed a framework for appropriate use of technology. This framework incorporates four guidelines. The first guideline is that learning occurs in context. In order to follow this guideline, teachers can incorporate technology into the classroom as a means of introducing students to real world situations and experiences. This framework also stated learning is active. This guideline can be met when teachers incorporate student directed learning into their classroom. Student directed learning can be fostered by the interactive whiteboard technology. Learning was viewed as social in this framework. Information and communications technology create a social network via technology. These technologies can be utilized in the classroom via the interactive whiteboard as a means to reaching this guideline. Finally learning is believed to be reflective. Technology can be utilized to promote discussion and reflection throughout the class (Ozel, Yetkiner, & Capraro, 2008).

Along with this framework, Ozel, Yetkiner, and Capraro (2008) contended there are three prerequisites that must be met to successfully utilize technology in the classroom. First, students and teachers alike must have equal access to the technology. Technology usage should not be dominated by one group. Second, teachers need to be fully trained in the technology as well as how to utilize the technology as a means to
improving instruction. Finally, technology support needs to be provided to teachers. This support needs to be timely and offer ways to further advance the teacher’s use of technology in the classroom (Ozel, Yetkiner, & Capraro, 2008).

**Instructional Interaction.** Interaction plays a key role in the successful adoption of the interactive whiteboard into the classroom. Kahveci and Imamoglu (2007) offered a definition to interactivity. They define it as “an action that occurs as two or more objects have an effect on each other” (p. 138). Specifically, interaction refers to a two-way effect. Each object has an effect on the other. In terms of instructional interaction in regards to technology, interactivity is seen between the teacher, students, and the technology itself (Kahveci & Imamoglu, 2007).

Kahveci and Imamoglu (2007) held that interaction plays a key role in learning. They site both Wagner and Vygotsky as supporters of this theory as well. Learning can be seen as occurring when a student interacts with his/her environment. Interaction involves strategies that learners employ such as elaboration, control, and motivation. The types of interactions we see in the student’s learning environment involve the student and the instructional technology (Kahveci & Imamoglu, 2007).

The quality of learning depends on the type of interaction the technology requires of the student as well as the technology’s ability to respond to the student’s input (Kahveci & Imamoglu, 2007). If the technology is able to actively involve the student in the process as well as accurately respond to the student, Kahveci and Imamoglu (2007) believed a change in the student’s behavior that pushes him/her towards an educational goal will occur.
The three-way interaction that occurs among the teacher, students, and interactive whiteboard is key to the successful implementation of interactive whiteboard technology in the classroom. When the interactive whiteboard is utilized in an enhanced interactive way that involves students in their learning, meaningful learning can occur (Wood & Ashfield, 2008). In fact, Tanner and Jones (2007) claimed that the interactions created by the presence of the interactive whiteboard in the classroom create a learning environment that supports effective learning.

**Student Directed Learning.** Successfully implementing the interactive whiteboard into the classroom requires instructional practices to focus on the student. The student needs to be the one driving the learning. The interactive whiteboard provides situations in which students can be more autonomous in their learning (Tanner & Jones, 2007). When students were allowed to take responsibility for their learning, they gained a sense of ownership and control (Wood & Ashfield, 2008). This strong sense of responsibility for their learning can help increase student attainment through improved motivation levels.

Interactive whiteboards do not naturally encourage student directed learning (Tanner & Jones, 2007). Access to the technology remains under the control of the teacher. Therefore, teachers have to be willing to utilize the interactive whiteboards in a way that require student participation and interaction. The technology should be used to engage students. Teachers need to have the goal of reaching enhanced interactivity with the technology (Blanton, 2008). Along these lines, teachers need to create a social, lively classroom environment in which students feel in control of there learning and
comfortable in interacting with the technology in order for the interactive whiteboard to have a significant impact on student achievement (Wood & Ashfield, 2008).

While creating a classroom environment that encourages student directed learning, a change in teacher and student roles needs to occur. Specifically, the students take on a teacher role in the classroom while the teacher becomes a student. Merrett and Edwards (2005) found teachers needed to learn new skills and become competent in the technology in order to successfully incorporate the interactive whiteboard into their classroom.

Also, with the wealth of resources available through information and communications technology via the interactive whiteboard, teachers need to be able to accept the fact that it is okay to let their students know they do not have the answers all the time. The interactive whiteboard makes it easy for teachers and students to research questions and discover answers and new learning together. Teachers need to move from the traditional role to a role of facilitator (Hall & Higgins, 2005).

Tanner and Jones (2007) contended that the role of teaching and learning must be shared with the students. This sharing leads to deep levels of interaction which in turn increases student achievement and motivation. In many cases, students are greater equipped in terms of technology use. Students are familiar with technology and able to easily learn and adapt to new forms of technology in the classroom. It may be the case that teachers learn about interactive whiteboard technology through their students. Also, with student use of the interactive whiteboard, students can become the experts in one area and be responsible for teaching that information to the rest of the class as well as the teacher.
Mildenhall et al. (2008) viewed the teacher’s role in a classroom with interactive whiteboard technology is to allow interactivity and create learning situations that require enhanced interaction which leads to deep discussion. Teachers need to create lessons and utilize the interactive whiteboard in a way that actively engages students. Active engagement is key to the success of the interactive whiteboard. In order to do so, many teachers need to change their style of teaching (Mildenhall et al., 2008).

The Role of Interactive Whiteboards in Mathematics Instruction

Technology integration in the mathematics classroom is being viewed as an essential way in which to better prepare students for their future (Kahveci & Imamoglu, 2007). Interactive whiteboards are considered an important technology in the mathematics classroom that supports different teaching and learning styles (Ozel, Yetkiner, & Capraro, 2008). Tanner and Jones (2007) believed the introduction of interactive whiteboards into the mathematics classroom provides many opportunities for engaging, interactive lessons. They warned, however, that learning how to successfully utilize the interactive whiteboard as a means to increasing student achievement and motivation in mathematics is a complex process that requires more than technical training (Tanner & Jones, 2007).

Kahveci and Imamoglu (2007) found the interactive whiteboard to increase mathematical achievement, higher order mathematical skills, and metacognition. However, these positive findings were only seen in situations where students were required to communicate mathematically as well as interact with their peers, teachers, and the technology (Kahveci & Imamoglu, 2007). Kahveci and Imamoglu (2007) determined that careful planning needed to occur in order to achieve such results. They offered
several steps to follow when implementing the interactive whiteboard in the mathematics classroom. The steps are as follows: students should be encouraged to use multiple representations to develop problem-solving strategies; students’ motivation to learn should be mastery goal oriented; teachers should create contexts for mathematical argumentation; teachers should encourage student participation in classroom discussions; students should be expected to provide mathematical reasoning rather than producing the right answer; design of tasks should be suitable to promote skills such as mathematical reasoning and metacognition (Kahveci & Imamoglu, 2007).

The interactive whiteboard holds huge possibilities in terms of increasing student achievement and motivation. However, teachers need to utilize the technology in an effective way in the classroom in order to see positive results. Teachers can follow the guidelines mentioned above. It is also important for teachers to understand how to design interactive lessons and the various resources available to them through the interactive whiteboard.

*Designing Interactive Lessons.* Teachers with an interactive whiteboard have a wide range of resources available to support their mathematics teaching and increase the interactivity of their lessons (Kent, 2006). Graphing calculators, spreadsheet programs, and mathematics-based software are all a finger touch away via the interactive whiteboard. The interactive whiteboard offers immediate access to the Internet. Teachers should utilize this resource as a means to create real world learning situations (Kent, 2006). Interactive websites utilized to investigate mathematical concepts are available through the Internet as well (Ozel, Yetkiner, & Capraro, 2008).
Software that comes with the interactive whiteboard allows teachers to design interactive lessons. Teachers can promote higher order thinking skills through the software (Kent, 2006). Information can be presented in a problematic way that requires class discussion and multiple interpretations. Teachers can utilize the software as a window into student mathematical thinking and understanding of concepts. The open-ended thinking and discussions that are promoted by the interactive whiteboard allow students to function above their arithmetic abilities (Kent, 2006). The interactive whiteboard can be utilized by students to explore mathematical concepts. It also can be utilized by the teacher as a means of modeling operations and learning to the whole class (Kent, 2006).

Perhaps the biggest impact the interactive whiteboard has on student achievement and motivation comes from its ability to bring the real world into the mathematics classroom. Teachers can modify lessons in order to engage students with real world problems. This allows students to see a connection between mathematics and the world they live in. This benefits student motivation and achievement in several ways. First, the students are connected with the world beyond the classroom. Also, students are excited to see how their learning is relevant in their everyday life (Kent, 2006). Teachers should utilize real world situations and connections in the mathematics classroom via the interactive whiteboard.

Teachers should offer students a chance to experiment and explore mathematics through the interactive whiteboard (Tanner & Jones, 2007). The features of the interactive whiteboard technology allow the opportunity for interactive learning. Students are able to try their own ideas and present them to their peers and teacher.
There is no fear of failure because mistakes can easily be fixed. When teachers allow their students to experiment, students are no longer afraid to take risks in their learning (Tanner & Jones, 2007).

*Virtual Manipulatives.* Virtual manipulatives offer a unique way to create interactive mathematics lessons via the interactive whiteboard. Virtual manipulatives can be defined simply as virtual representations of physical manipulatives (Mildenhall et al., 2008). Students utilize manipulatives to represent mathematical concepts. Virtual manipulatives are these same representations on the interactive whiteboard via the computer. According to Mildenhall et al. (2008), manipulatives are created and designed to promote conceptual thinking. They allow students to work with abstract mathematical ideas. Virtual manipulatives offer these same benefits.

There are several advantages to utilizing virtual manipulatives in the mathematics classroom (Mildenhall et al., 2008). First, they are free and can be easily searched through the Internet. The National Library of Virtual Manipulatives offers a wealth of manipulative resources to teachers and students. Second, virtual manipulatives can be utilized at home by parents and students alike, whereas teachers may be reluctant to send physical manipulatives home with students. Virtual manipulatives are a worry free way of assigning projects and homework that utilize manipulatives. They appeal to older students more so than physical manipulatives. Virtual manipulatives appear to be more sophisticated and therefore older students are engaged by them (Mildenhall et al., 2008).

Virtual manipulatives allow whole class instruction to easily occur. The teacher can utilize virtual manipulatives in her instruction. Students can model through virtual manipulatives as well. Any manipulative teaching that occurs can be supported through
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virtual manipulatives on the interactive whiteboard (Mildenhall et al., 2008). Interactive computer programs, such as Geometer’s Sketchpad, can be utilized in a whole group setting as well. Through the interactive whiteboard and virtual manipulatives students are presented with multiple representations that support student understanding. They also allow students to interact with mathematical concepts in an engaging way (Ozel, Yetkiner, & Capraro, 2008).

Summary

Overall, the literature points to a significant positive impact on student achievement and motivation in mathematics through the utilization of the interactive whiteboard in the classroom. Merrett and Edwards (2005) held that the interactive whiteboard allows students to experience a wide range of examples as well as visual explanations for abstract mathematical concepts that are being learned. This same study found there to be improvement in the mathematical thinking skills of students in classrooms that utilize interactive whiteboard (Merrett & Edwards, 2005). Specifically, students became more confident in their thinking, understanding, and discussion of mathematical concepts. Merrett and Edwards (2005) stated that students in classrooms with interactive whiteboards display a deep understanding of mathematics.

Schweder and Wissick (2008) attributed the positive impact to the interactive whiteboard’s ability to enable teachers to demonstrate and illustrate mathematical concepts. Their study noted that the key components in mathematics curricula, mathematics computation and reasoning, increased for students in classrooms with interactive whiteboard technology (Schweder & Wissick, 2008). Along these same lines, Ozel, Yetkiner, and Capraro (2008) discovered a positive correlation between computer
use and student achievement. Specifically, they state that when the technology is integrated effectively into teaching and learning, student proficiency in mathematics increases (Ozel, Yetkiner, & Capraro, 2008).

Smith, Hardman, and Higgins (2006) contended that the interactive whiteboard engages students in a way that traditional teaching cannot. Merrett and Edwards (2005) found students to prefer discovering mathematical concepts for themselves. Students enjoy presenting their learning to their peers as well as teaching lessons to their class. The student directed learning fostered by interactive whiteboards help to motivate students in the mathematics classroom (Merrett & Edwards, 2005).
Methodology

With the knowledge of the United States’ relatively low academic ranking worldwide, technology has come to the forefront of educational theory. It is being viewed as the means towards increasing student attainment and motivation. Specifically, research is pointing towards the use of interactive whiteboards in the classroom as a catalyst for this increase. The literature holds that interactive learning via technology is an extremely motivating classroom situation in which students learn to actively participate in and take responsibility for their own learning.

However, simply introducing an interactive whiteboard into the classroom does not automatically guarantee positive results. Teachers need to be trained in how to utilize the interactive white board in a highly interactive way. It is natural for teachers to rely on their previous knowledge and understanding of instructional technology when working with the interactive whiteboard. Therefore, many teachers utilize the interactive whiteboard simply as a presentational tool. When teachers utilize the interactive whiteboard interactively in their lessons and allow the students to take control of their own learning, increases in academic achievement and motivation can be seen.

This study aimed to investigate how teachers can effectively incorporate the interactive whiteboard into the mathematics classroom with the purpose of increasing student achievement and motivation. Previous research findings on effective uses and strategies involving the interactive whiteboard have been incorporated into this study. A comparison of three classrooms; one without an interactive whiteboard, one with an interactive whiteboard being utilized in a traditional way, and one with an interactive
whiteboard utilizing the research-supported strategies was conducted. Student mathematical achievement and motivational levels were assessed and compared.

**Participants**

Fifty-four third grade students, 28 male and 26 female, from the Byron Bergen Elementary School in Bergen, New York were selected for this study. The 54 subjects made up three third grade classrooms, with 18 students in each. Classroom A had 9 boys and 9 girls with no students with IEPs. Classroom B had 9 boys and 9 girls with 2 with students with IEPs. Classroom C had 10 boys and 8 girls with 3 students with IEPs. The students’ ages ranged from 7 to 9 years old. All students were participating in the Byron Bergen Central School District-appointed Scott Foresman Math Investigations curriculum.

Each classroom was selected to participate based on the varying levels of interactive whiteboard use. Classroom A did not have an interactive whiteboard. Classroom B did have an interactive whiteboard that was utilized in a traditional, presentational method. Classroom C did have an interactive whiteboard. Classroom C implemented the research-based strategies aiming towards utilizing the interactive whiteboard in a meaningful, interactive way.

**Instruments and Materials**

Prior to beginning the multiplication unit, subjects were given the Interactive Whiteboard (Appendix B) and Mathematics (Appendix C) surveys. The Interactive Whiteboard survey asked students questions regarding the interactive whiteboard. Students were asked what they liked and did not like about the interactive whiteboard. Students were also asked how they would utilize the interactive whiteboard if they were
the teacher. The Mathematics survey looked into the students’ perceived level of mathematic achievement and motivation. These surveys were taken again at the end of the unit to see if student views had changed over the course of the unit.

Virtual manipulatives and interactive games available at no cost via the Internet were utilized in the study. These included the National Library of Virtual Manipulatives (Appendix E) which displayed multiplication through the use of arrays. The Area Models for Multiplication and Division website (Appendix G) utilized rectangles as well. Both of these virtual resources imitated the array cards that were utilized in the classroom and provided by the Scott Foresman Math Investigations curriculum. Virtual multiplication games (Appendix H) were played during centers to reinforce multiplication concepts and facts recall. A multiplication table (Appendix F) was also utilized.

Students participated in a Mad Minute Multiplication activity at the beginning of each class period. These worksheets (Appendix D) incorporated approximately 30 multiplication facts questions. Students were to answer as many questions correctly as they could in a time frame of one minute. An interactive Mad Minute Multiplication website (Appendix I) complemented this activity. The purpose of these activities was to test the students’ recall of multiplication facts.

Several times throughout the study, students were asked to complete a Ticket Out (Appendix A). The Ticket Out was a worksheet that asked students to answer a multiplication question and explain or show how they know their answer is right. The purpose of the Ticket Out was not only to test the students’ recall of multiplication facts
but also to check for understanding of the mathematical concepts underlying multiplication.

The interactive whiteboard was utilized in every lesson for classroom C. PowerPoint lessons were designed for and utilized during the guided instruction portions of the unit (Appendix J). The teacher utilized the PowerPoint presentation and interactive whiteboard to open up dialogue and discuss mathematical concepts. Students were allowed to explain and demonstrate their thinking via the interactive whiteboard.

At the end of the unit, all third grade classrooms in Byron Bergen Elementary School completed the Unit 5 Test Multiple Choice and Short Answer sections provided by the Scott Foresman Math Investigations Series (Appendix K and Appendix L). The scores of the three classes involved in the study were collected and compared. The students also took the Interactive Whiteboard and Mathematics Survey again.

Data Collection

There were four areas of data collection in this study. Prior to beginning the unit, students completed two surveys. These surveys delved into the students’ views on the interactive whiteboards and achievement and motivation in mathematics. The subjects took these surveys again at the end of the unit. The surveys were utilized to determine if the interactive whiteboard’s presence and type of use had an effect on student views. Also, the surveys were utilized to determine if student views had changed over the course of the unit.

At the beginning of each lesson, all subjects completed a Mad Minute Math worksheet. These worksheets tested the students’ recall of multiplication facts. The
mean, median, mode, and range of each group was analyzed and compared to determine if there was a significant difference among the groups.

Four times throughout the unit, all subjects completed a Ticket Out. These worksheets required students to solve one multiplication problem and explain how they arrived at their answer. The quality of the explanations were analyzed and compared among the three groups (Appendix N).

At the end of the unit, all subjects completed the Scott Foresman Math Investigations Series Unit 5 Multiple Choice and Short Answer Test. The scores from all subjects were collected and analyzed.

Procedures

The study took place over 24 school days. Students were taught one lesson from the Scott Foresman Math Investigations’ Series a day. Prior to beginning the Unit 5 study on multiplication parents of students in Classroom C were sent home a letter regarding multiplication strategies and tricks to help their child learn the multiplication facts. This letter also included a list of the virtual resources that would be utilized in class and can be accessed through their home computer. All subjects were given two surveys prior to beginning the multiplication unit. Students from all three groups completed the Interactive Whiteboard survey and the Mathematics survey.

All three classrooms participating in the study completed a Mad Minute Multiplication worksheet at the beginning of every lesson. This resulted in 24 Mad Minute Multiplication worksheets being given throughout the unit. Students were given one minute to answer as many multiplication questions as possible correctly.
Every five days students in all three groups were given a Ticket Out. This resulted in a total of four Ticket Outs throughout the unit. Each Ticket Out had a different multiplication fact for students to solve. Once solved, students were required to explain/show how they reached their answer.

Classroom A proceeded to teach the multiplication unit according to the Scott Foresman Math Investigations Series. The lessons were followed as typed in the textbook and Teacher Manual. Worksheets (Appendix P) from the Series were provided to students. Supplementary material was provided during the unit as well (Appendix Q). An interactive whiteboard was not utilized in the classroom.

Classroom B taught the multiplication unit according to the Scott Foresman Math Investigations Series, as well. As with Classroom A, the lessons were followed as typed in the textbook and Teacher Manual. Worksheets from the Series were provided to students. An interactive whiteboard was present in classroom. However, it was only utilized as a presentational tool. There was no supplementary material via the interactive whiteboard.

Classroom C utilized the interactive whiteboard in all lessons. The teacher created PowerPoint presentations based on the outline of the lesson provided in the Scott Foresman Math Investigations Series. The PowerPoint presentations were utilized during guided instruction as a means of inspiring mathematical dialogue and allowing students to express their mathematical thinking.

In Classroom C, each lesson began with the students completing the Mad Minute Multiplication worksheet for that day. Next, the whole class was led through a guided instruction activity by the teacher. During this time the teacher modeled multiplication
strategies and introduced new concepts to the students. Students were called to the interactive whiteboard to try sample problems and share their thinking with the class. The guided instruction portion of the lesson followed the Scott Foresman Math Investigations lesson closely. However, the teacher made sure to encourage student dialogue and utilize the interactive whiteboard in an interactive way not just as a presentational tool. Virtual Manipulatives and other websites were utilized by the teacher and students during this time to demonstrate multiplication.

Following the guided instruction portion of the lessons in Classroom C, students were split into centers. There were three centers throughout the classroom. At the teacher center, students continued to work on multiplication facts and concepts with the teacher. At the game center, students played multiplication games that were provided by the Scott Foresman Math Investigations Series. Finally, at the SMART Board Center students were able to work with the virtual manipulative presented and utilized at the beginning of the lesson, play a multiplication game, or practice multiplication facts on the interactive whiteboard.

On the 24th day, all three groups completed the Unit 5 Multiple Choice and Short Answer Test provided by Scott Foresman. Scores were collected for all students and compared among the three groups.
Results

Data was collected over a period of 24 days. Student responses to surveys were qualitatively analyzed in respect to the students’ achievement and motivation regarding mathematics. Scores on the Mad Minute Math worksheets were compared regarding the number of multiplication facts correct in one minute. Ticket Out worksheets were analyzed according to a correct response as well as the ability to explain or show how the student arrived at the answer. Finally, the end of the unit assessment test and worksheet compared the mean, median, mode, and range among the three different classrooms.

Student Surveys

Students in all three classrooms responded in a similar way on the Mathematics Survey (Appendix C). The greatest difference was seen in the favorite subject area response as well as when indicating what was liked and not liked about Math. Students in both Classroom B and Classroom C commented on the interactive whiteboards during these responses. There was a significant difference in the responses given by Classroom B and Classroom C on the Interactive Whiteboard Survey (Appendix B).

Mathematics Survey. When asked what their favorite subject is, students in Classroom A had a wide range of responses including Math, English, Social Studies, and Science. The majority of students in both Classroom B and Classroom C chose Math as their favorite subject area with 11 students from Classroom B and 12 students from Classroom C responding in this manner.

In all three classrooms the vast majority of subjects stated that Math was easy for them and that they enjoyed math as a class. Fifteen of the 18 students in Classroom A indicated Math as being easy for them. Sixteen students in Classroom A stated that they
lik Math. Similarly, 17 students in Classroom B and 16 students in Classroom C felt that Math was easy for them. All 18 subjects in both Classroom B and Classroom C responded with a yes to liking Math.

All three classrooms had similar responses to the questions “What do you like about Math?” and “What don’t you like about Math?” Students mentioned that they liked adding, subtracting, drawing pictures, and counting money. One difference that was noted was that Classroom C had responses that involved the interactive whiteboard. Students from Classroom C commented on enjoying going to websites to play math games during center time. Students from all three classrooms stated that they did not like borrowing, taking tests, and having math homework.

When asked what their favorite part of using the SMART Board in Math was, students in Classroom B responded with mainly presentational uses of interactive whiteboards. Students from this classroom commented on the interactive whiteboard’s ability to make things easy to see and the ability to write on the interactive whiteboard. Students from Classroom C commented on the interactive nature of the technology. Students stated that they enjoyed playing math games on the interactive white board, solving problems on it, writing on it, and having the opportunity to solve math problems on it.

When the survey was given again at the end of the unit, many responses were similar. Students in all three classes responded the same way they had at the beginning of the unit when asked what their favorite subject in school is. Classroom A had a wide range of responses once again. The responses included Math, English, Social Studies, and Science. As seen earlier, the majority of students in both Classroom B and
Classroom C chose Math as their favorite subject area with 11 students from Classroom B and 12 students from Classroom C responding in this manner. All three classrooms had similar responses to the question “What don’t you like about Math?” during the second survey as well. Students once again mentioned that they did not like borrowing, taking tests, and having math homework.

Differences were seen regarding the question “What do you like about Math?” Both Classroom A and Classroom B responded with answers very similar to the ones they had given at the beginning of the unit. Students mentioned that they liked adding, subtracting, drawing pictures, and counting money once again. Classroom C gave new responses to this question. Many responses discussed specific multiplication activities that had been performed throughout the unit as well as the different ways in which the SMART Board was utilized during the unit as being an area the students liked in Math. Students from Classroom C listed multiplication games on the SMART Board, utilizing array cards, learning multiplication, and practicing multiplication problems on the SMART Board as things they liked about Math.

Differences were also seen regarding the question “What is your favorite part of using the SMART Board in Math?” This question was given to both Classroom B and Classroom C. The students in Classroom B once again focused on the presentational aspects of the SMART Board. These students commented on the interactive whiteboard’s ability to make things easy to see and the ability to write on the interactive whiteboard. Students from Classroom C once again focused on the interactive nature of the technology and stated specific instances in which the SMART Board was utilized during the multiplication unit. Student responses included that they enjoyed playing
math games on the interactive whiteboard, solving problems on it, writing on it, and having the opportunity to solve math problems on it.

*Interactive Whiteboard Survey.* The interactive whiteboard survey displayed student responses from Classroom B that focused mainly on the technology provided by the interactive whiteboard while the responses from Classroom C focused more on the interactivity. When asked what students like about interactive whiteboards, students from Classroom B responded by describing the technology. Responses included things such as the Internet, a calculator, and the ability to draw on the interactive whiteboard. One student described the interactive whiteboard as “a big computer you can touch.” Students from Classroom C mentioned that they enjoy playing games on the interactive whiteboard, making pictures, and writing on it. One student stated that he enjoys the fact that he can “go up to touch it.”

Both groups mentioned technological difficulties associated with the interactive whiteboards as being problems. Classroom B’s responses mentioned the fact that only one person can be using the interactive whiteboard at a time. The students also did not like that you can not touch the board with your other hand when writing or that if you touch it in a certain way your work can be erased. Students from Classroom C do not like that you have to orient the interactive whiteboard. Their responses indicate that the board has to be oriented all the time and it takes time away from what they are learning. Both classes mentioned that the interactive whiteboard can be slow at times and takes a long time to load certain programs.

Students were asked to suggest things that would make the interactive whiteboard even better. Both classes once again focused on problems with the technology and
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equipment. Classroom B’s responses included making the board bigger, having more pens to write with, and having the interactive whiteboard never break down.

Interestingly, one student in Classroom B mentioned that the interactive whiteboard would be better if you could play games on it. Classroom C’s suggestions included not having a projector, not needing to orient the board or to have the board orient itself, and to not have such a bright light in the projector. One student from Classroom C requested that the interactive whiteboard automatically correct misspelled words, punctuation, and capital letters.

The final question asked the subjects how they would use the interactive whiteboard if they were the teacher. Classroom B’s students mentioned many interactive ways that they would like to utilize the interactive whiteboard. Student responses included utilizing the Internet, playing games, and teaching all subject areas with the interactive whiteboard. Classroom C’s responses were very similar. Students mentioned playing math games, teaching all subject areas with the interactive whiteboard, and utilizing the interactive whiteboard in art projects and writing pieces.

When given the interactive whiteboard survey once again at the end of the unit, students from both classrooms responded in similar ways to the first survey. Once again Classroom B focused mainly on the technology provided by the interactive whiteboard while the responses from Classroom C focused more on the interactivity. Both groups still mentioned technological difficulties associated with the interactive whiteboards as being problems. When asked to suggest things to make the interactive whiteboard even better, both classes once again focused on problems with the technology and equipment. The final question of how students would utilize the interactive whiteboard if they were
the teacher garnered similar responses. Both groups focused on utilizing the interactive whiteboards in interactive ways. One difference that can be noted is that Classroom C included the names of specific interactive math games that can be utilized on the interactive whiteboard. Classroom B simply made comments about drawing and writing on the interactive whiteboard.

*Mad Minute Math*

While Mad Minute Math worksheets were given everyday throughout the unit, four sets of these worksheets were collected as data for this research. All three classrooms performed at similar levels for all four of the worksheets. Classroom C scored the highest with an average of 83% on the first worksheet (Table 1). Classroom A recorded an average of 81% and Classroom B an average of 79% on the first worksheet. Classroom A scored the highest on the second worksheet with an average of 86% (Table 2). Classroom C followed closely behind with an average of 84% and Classroom B had an average of 82%. Classroom C had an average of 86% on the third worksheet. Classroom A had an average of 85%. Classroom B had an average of 82% on the third worksheet (Table 3). Finally, Classroom C had the highest average on the fourth worksheet. Classroom C’s average was an 89%. Classroom A’s average was an 87%. Classroom B’s Average was an 85%. For all four worksheets, Classroom C had the largest range (Tables 1 – 4).

*Tickets Out*

There were four sets of Ticket Out worksheets given throughout the unit. The first Ticket Out worksheet asked the multiplication fact eight times three. Four students from Classroom A, one student from Classroom B, and two students from Classroom C
gave the wrong answer to the problem. The second Ticket Out worksheet asked the multiplication fact six times two. All students in both Classroom A and Classroom C answered this question correctly. There was one student in Classroom B who provided a wrong answer to the problem. The third Ticket Out worksheet asked the multiplication fact four times five. All students in all three classrooms answered this question correctly. The fourth Ticket Out worksheet asked the multiplication fact eight times nine. All students in all three classrooms answered this question correctly, as well.

The Ticket Out worksheets were evaluated utilizing a rubric with a maximum score of 4 points (Appendix N). For each of the Ticket Out worksheets all students, including the ones that arrived at the wrong answer, demonstrated effective multiplication strategies. Some of the strategies discussed by the students included repeated addition, drawing pictures of groups, and making arrays. While these exemplary strategies were seen in all three classes, they were not seen as much in Classroom A and Classroom B. A typical response for students from Classroom A was that they used a Hundreds Chart or counted on their fingers to discover the answer (Figure 1). A typical response for students from Classroom B was that they skip counted or counted up (Figure 2). Whereas, students in Classroom C were able to display the mathematical theory behind multiplication via repeated addition, drawing groups, or drawing arrays (Figure 3). Classroom C scored higher on all four Ticket Out worksheets when compared to the other classrooms (Tables 5 – 8). Classroom A scored the lowest for the first Ticket Out (Table 5). However, Classroom B scored lower than Classroom A for the last three Ticket Out worksheets (Tables 6 – 8).
End of Unit Assessment

At the end of the unit, all students took a multiple choice unit assessment as well as a short answer unit assessment. The multiple choice unit assessment was scored out of a possible 100%. Classroom A scored the highest with an average of 81%. Classroom C had an average of 78% while Classroom B had an average of 73%. Classroom C had the largest range of numbers (Table 9). The short answer unit assessment was scored out of a possible 4 points. All 3 classrooms scored an average of 3 points. Once again, Classroom C had the largest range of numbers (Table 10).
Discussion

The results of the research were consistent with the literature. Overall, students in the classroom utilizing the interactive whiteboard in the most interactive way performed at a higher level academically when compared to the other two classrooms. Also, student responses to the survey questions indicated a greater motivation to learn as well as a greater understanding of how the interactive whiteboard can be utilized to benefit their education.

While all three classrooms performed very well with the majority of students meeting or exceeding the New York State Learning Standards, Classroom C performed at a higher level with regards to the Mad Minute Math worksheets and Tickets Out. Classroom A performed slightly better on the End of Unit Multiple Choice Assessment. All three classrooms performed the same on the End of Unit Short Answer Assessment.

Students in Classroom C were able to answer more multiplication questions correctly in one minute on the Mad Minute Math worksheets when compared to the other two classrooms. Their performance on the Mad Minute Math worksheets indicates an ability to quickly recall multiplication facts and correctly answer these problems. Schweder and Wissick (2008) found that interactive whiteboards allow teachers to demonstrate mathematical processes that in turn increase student mathematical computation. Therefore, the results of the current study could be due to the way in which multiplication facts were presented in each classroom.

First, the teacher in Classroom A strictly followed the Scott Foresman Math Investigations Series. This series focuses on real world applications and students discovering mathematical concepts on their own. There is little focus on numeracy
Increasing Student Achievement 55

fluency within this program. While the students in Classroom A did participate in a Mad Minute Math worksheet every lesson, there was no time set aside for studying multiplication facts and practicing to become fluent in them.

Students in Classroom B spent some time on a regular basis studying multiplication facts from flash cards. They also practiced on supplementary worksheets that were provided throughout the unit. However, the interactive whiteboard was not utilized as a means to learn multiplication facts and increase student fluency. Students simply were expected to memorize the facts and be able to record the answers on a piece of paper.

The students in Classroom C practiced their multiplication facts on the interactive whiteboard. Interactive websites that recorded the number of facts correct over a period of time were utilized in the lessons. Students raced against themselves, each other, and competed in groups. This motivated the students to learn their facts in order to be able to correctly answer the questions on the interactive whiteboard. The competitive atmosphere also contributed to the students’ motivation. The high motivation to learn the multiplication facts in turn resulted in higher academic performance.

Ozel, Yetkiner, and Capraro (2008) found positive effects associated with the interactive whiteboard to include improved attitudes toward learning and an engagement with mathematics. These findings were replicated in the current study. This level of motivation and achievement was not reached in the other two classrooms. Racing against themselves to increase their score on the Mad Minute Math worksheets was not enough of a motivator for the students. Studying multiplication cards and working on supplementary worksheets did not motivate the students either. Not only did the use of
the interactive whiteboard make a difference in Classroom C’s performance but the way in which it was utilized played a major role. Consistent with the findings in Ozel, Yetkiner, and Capraro’s (2008) study, the students were excited to display their learning for the whole class to see. Utilizing the interactive whiteboard in an interactive way that allows students to take control of their own learning is key in not only motivated the students but also in seeing increases in student achievement.

A high level of achievement was seen through the Ticket Out assessments for all subjects. All three classrooms performed extremely well on these worksheets. However, Classroom C scored higher on three of the four Ticket Out worksheets. Classroom A was slightly higher than Classroom C on the last Ticket Out worksheet administered. Students from all three classrooms were able to successfully utilize different strategies to arrive at the correct answer to a multiplication equation. However, students in Classroom C demonstrated a higher level of understanding of the mathematical concepts behind multiplication through their responses.

When asked how they solved the multiplication equation, a typical response from students in Classroom A and Classroom B was that they utilized a Hundreds Chart or counted on their fingers. While these are both strategies that students are able to utilize successfully, they do not demonstrate the mathematical concepts underlying multiplication. Whereas, a typical response from students in Classroom C included drawing arrays, making groups, or showing repeated addition.

This is consistent with research performed by Merrett and Edwards (2005). Merrett and Edwards (2005) discovered a significant improvement in mathematical thinking skills for students in classrooms with interactive whiteboards. Also, these
students were more confident in their mathematical reasoning and were able to display a deep understanding of mathematics through discussion and explanation (Merrett & Edwards, 2005).

The differences in student responses on the Ticket Out worksheets once again could be the result of the utilization of the interactive whiteboard. Through the availability of virtual manipulatives, Classroom C was able to work with arrays on the interactive whiteboard. Instead of having to draw arrays, the students could easily manipulate the interactive websites. This resulted in students being able to solve large multiplication problems through arrays. Also, the students were excited to have the opportunity to work with arrays on the interactive whiteboard.

Along these same lines, students in Classroom C enjoyed websites and virtual manipulatives that helped students to create groups to solve multiplication problems. The ability to manipulate these manipulatives into answering any multiplication question that was posed to the students really motivated the students. The students were able to transfer this learning to paper when asked too.

Mildenhall, Swan, Northcote, and Marshall (2008) found virtual manipulatives to promote abstract mathematical thinking. They viewed the ability to utilize virtual manipulatives in a whole class setting via the interactive whiteboard as being extremely beneficial. The research found the virtual manipulatives to be a support to the mathematical learning that is taking place. Students were able to transfer their learning from the virtual world to real world situations and problems (Mildenhall, Swan, Northcote, & Marshall, 2008). The results from the current study were consistent with Mildenhall, Swan, Northcote, and Marshall’s (2008) findings.
Students in both Classroom A and Classroom B worked with arrays, making groups, and repeated addition as well. However, these strategies were not demonstrated or practiced on an interactive whiteboard. Students were responsible for drawing the arrays and groups on paper. While students were taught these strategies, these strategies were not the strategy of choice. Students did not transfer this learning to new multiplication situations. Also, students from these two classrooms did not rely on these strategies when problem solving. Instead, they utilized strategies they had learned in previous lessons such as utilizing a Hundreds Chart.

The results seen from the Ticket Out worksheets indicate that students need to be motivated by what they are learning in order to retain that information and transfer it to new situations. The interactive whiteboard can be a great way to achieve student motivation and as a result increase student achievement. Students in all three classrooms were taught the same strategies. However, students who were given the opportunity to work with these strategies on the interactive whiteboard were the students who utilized these strategies when asked to solve multiplication equations. It is important for teachers with interactive whiteboards to allow students to utilize the interactive whiteboards in interactive ways that support their learning. When students are given the opportunity to take control of their own learning through the use of technology their motivation levels and achievement levels increase.

Students in Classroom A received the highest scores on the End of Unit Multiple Choice Assessment. They scored three percentage points higher than students in Classroom C. Classroom B was eight percentage points below students in Classroom A. While it was theorized that the students in Classroom C would perform higher than the
other two classrooms, it is not a surprise that Classroom A did very well. Classroom A has a very experienced teacher who likes to focus on problem solving. The majority of questions on the End of Unit Multiple Choice Assessment are word problems. Therefore, the students in Classroom A were very well prepared for this type of test.

Also, Classroom A did not have any students with Individualized Education Plans. Both Classroom B and Classroom C had students with Individualized Education Plans. These students have difficulties with test taking. They required the assessment to be read aloud to them and required extended time. This could have played a factor into Classroom B and Classroom C’s performance on the assessment. These students in particular may not have done as well as the others. Along these same lines Classroom C had the largest range of scores when compared to the other two classrooms. An extremely low score could be pulling down the average and misrepresenting the achievement of the other students.

All students in the three classrooms performed extremely well on the End of Unit Short Answer Assessment. The three classrooms had the same average of three points. Students were required to answer three multiplication word problems on this assessment. Students were not asked to explain how they came to their answer. Therefore, students were only scored on whether they had the correct or incorrect answer to the question. As seen with the Ticket Out worksheets, all students are able to successfully answer multiplication equations. The difference lies in the strategies that are utilized. Because the strategies were not evaluated on this assessment, all three classrooms performed at the same level.
The End of Unit Assessments show that all subjects were able to successfully learn about multiplication and strategies to utilize when multiplying. Perhaps the difference lies in the students’ motivation as well as understanding of the mathematical concepts underlying multiplication. Knight, Pennant, and Piggot (2005) suggested that the power of the interactive whiteboard lies in its ability to create a positive learning environment that motivates students and engages them. While students in Classroom C did not perform better than the other classrooms on the End of Unit Assessments, their motivation and engagement with the multiplication lessons was easily seen and may have contributed to their success throughout the unit.

As stated earlier, students from Classroom C are able to utilize arrays, groups, and repeated addition to explain their answers to multiplication equations. Students from Classroom A and Classroom B relied on Hundreds Charts and counting on their fingers to solve their multiplication equations. Also, students from Classroom C are able to transfer the strategies they have learned to new problems and situations.

Similar to Jones’ (2004) findings that student enjoyment and motivation increased due to the utilization of interactive whiteboards, student motivation was higher in Classroom C than in the other two classrooms. This was seen in the responses provided to questions on the surveys that were administered. On both the beginning of the unit and end of the unit mathematics surveys, students in Classroom C provided responses that involved the interactive whiteboard. Students from this classroom indicated that they liked going to websites to play math games during center time. These responses were unique from the other two classrooms. Classroom A did not have an interactive whiteboard and therefore students did not have any experiences to write about.
Classroom B did have an interactive whiteboard. However, these students did not mention the technology in any of their responses. This indicates that the students were not engaged or motivated by the interactive whiteboard.

Along these same lines, when asked specifically about the interactive whiteboard, students in Classroom B discussed presentational uses of the technology. However, students from Classroom C commented on the interactive nature of the technology. Once again, these students listed specific examples of the technology being utilized in the classroom. Students mentioned playing math games on the interactive whiteboard, writing on it, and having the opportunity to solve math problems on it. Also, on the end of the unit survey, students from Classroom C discussed how the interactive whiteboard was utilized during the multiplication unit. Names of specific multiplication games were mentioned. The interactive arrays website was included in responses as well.

The frequency with which the interactive whiteboard was mentioned in student responses from Classroom C indicates a high level of student interest. The ability of these students to mention specific ways in which the interactive whiteboard was utilized and list these ways as things they enjoy about math suggests a high motivation level. These student responses were similar to the responses Hall and Higgins (2005) received when asking similar questions. Hall and Higgins (2005) received responses that indicated students feel interactive whiteboards make lessons more fun and enjoyable. Students from Classroom A and B did not mentioned specific activities that they enjoy about math. They also did not have responses that were as vivid and detailed as the ones from Classroom C.
Responses from Classroom B on the interactive whiteboard survey focused mainly on the technology provided by the interactive whiteboard. Classroom C’s responses focused more on the interactivity the technology provides. Student responses from Classroom B focused on describing the technology such as the big screen or the pens that can be used to draw on the interactive whiteboard. Students from Classroom C discussed playing games on the interactive whiteboard, making pictures, and writing on it. These responses indicate that students in Classroom C appreciated being able to interact with the interactive whiteboard while students with Classroom B still view the technology as mainly presentational and for teacher use. Once again these findings replicate Hall and Higgins (2005) findings that students are excited by the new capabilities the interactive whiteboard brings to the classroom.

Hall and Higgins (2005) discovered that not all student views are positive. Students do not like the technical problems associated with the interactive whiteboard. Students recognize the disruption, delay, and frustration these problems cause (Hall & Higgins, 2005). Similarly, both groups in the current study discussed technological difficulties associated with the interactive whiteboards as being problems. Student responses included the fact that only one person can be using the interactive whiteboard at a time. The students also did not like that they could not touch the board with their other hand when writing or that if one touches it in a certain way their work can be erased. Also, students do not like that they have to orient the interactive whiteboard. Their responses indicate that the board has to be oriented all the time and it takes time away from what they are learning. Both classes mentioned that the interactive whiteboard can be slow at times and takes a long time to load certain programs.
Students were asked to suggest things that would make the interactive whiteboard even better. All subjects focused on problems with the technology and equipment. Responses included making the board bigger, having more pens to write with, and having the interactive whiteboard never break down. Other suggestions included not having a projector, not needing to orient the board or to have the board orient itself, and to not have such a bright light in the projector.

These responses regarding technological difficulties are in line with other research findings (Hall & Higgins, 2005). Educators need to be sure that technical support is widely available for teachers and students alike. It is important for technological problems to be minimized in order for students to appreciate the technology as well as get as much as they can from it. Minimal technological problems would also help to keep teachers interested in utilizing the interactive whiteboard in their lessons. Without the right support, the technology will not be able to be utilized in an interactive way into the classroom. As students from Hall and Higgins’ (2005) study stated, if the interactive whiteboard is going to be effective, it needs to be in working order.

The students were also asked how they would use the interactive whiteboard if they were the teacher. All subjects mentioned interactive ways to utilize the technology. Classroom C was able to provide specific examples and names of websites and games that they would utilize in their classroom. All responses show that students want to be able to utilize technology. They appreciate the benefits that technology can provide to them in their learning. Students want instructional technology to be available to them and not just the teacher. The ability the students in Classroom C had to mention specific ways to utilize the interactive whiteboard in the classroom indicates that these students
enjoyed the activities they participated in and are motivated by them. These students would like the opportunity to participate in these activities again.

The responses to the surveys indicate that having the technology present in the classroom is not enough to engage and motivate students to learn. Students need to be actively involved with the interactive whiteboard in order for it to increase their motivational level. As Ward (2008) stated, the interactive whiteboards are meant for student use. When students are involved with the technology, their interest in the lesson increases and their motivation to learn the material is sparked by the ability to share their learning through the interactive whiteboard.

Educators need to recognize the importance of utilizing interactive whiteboards in interactive ways that allow students to take control of their own learning. The greatest results can be seen when students are given the opportunity to work with the interactive whiteboard and explore their learning via resources made available through the interactive whiteboard. Hall and Higgins (2005) found that when teachers take on a more flexible and collaborative approach to their teaching, the greatest benefits were seen in student achievement and motivation. The results of this study support these findings.

It is not enough to simply provide interactive whiteboard technology to classrooms. Teachers must be trained in how to utilize the interactive whiteboards at a highly interactive level. Professional development should be offered to all teachers regarding interactive whiteboard technology. Technical support must be made available to teachers. When the technology is not working, students are turned off from the learning and teachers are less likely to plan utilizing the interactive whiteboard in their lesson.
The interactive whiteboard has the potential to be a huge motivator in student learning as well as a catalyst towards increasing academic achievement. Students are captivated by the technology and want to utilize it in their learning. Lessons that incorporate whiteboard technology can sustain student attention and really benefit their learning. The interactive whiteboard is a valuable piece of technology capable of pulling students in to the lesson and providing a wide wealth of information right at the students’ fingertips.
Conclusion

The main emphasis of this research was to establish a positive correlation between the utilization of interactive whiteboards in the classroom and an increase in both student achievement and motivation in mathematics. There is evidence to indicate that such a relationship does exist. Specifically, students in the classroom that utilized the interactive whiteboard in the most interactive way had a deeper understanding of multiplication which was evidenced in their responses to the Ticket Out Worksheet (Figure 3) as well as their performance on the end of the unit assessments (Tables 5 and 6). These students were able to apply different multiplication strategies and understand the mathematics behind multiplication. This deep understanding was developed through interactively participating in and demonstrating multiplication strategies on the interactive whiteboard and through multimedia resources.

Also, student responses to the Interactive Whiteboard Survey (Appendix B) displayed evidence that students in the classroom that utilized an interactive whiteboard in a highly interactive way enjoyed math, found math to be easy, and were able to provide specific examples of utilizing the interactive whiteboard in math that they found interesting and exciting. The responses these students provided displayed their excitement and motivation for mathematics. These students wanted an opportunity to work with the interactive whiteboard and recognized the positive effect the interactive whiteboard was having on their learning.

It is important to note that there are clear implications for educators utilizing an interactive whiteboard in their classroom. Specifically, the interactive whiteboard technology itself can not bring about the pedagogical changes necessary to increase
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student achievement and motivation (Wood & Ashfield, 2008). Teachers need to have a clear understanding on how to utilize the interactive whiteboard in an effective way. It should not be utilized as merely a presentational tool. The research indicates that teachers need to take on the role of facilitator. The teacher is responsible for introducing the technology and multimedia capabilities to the students. Then the students need to take control of their own learning.

Unfortunately, incorporating technology into classroom instruction is a difficult feat for many teachers (Ozel, Yetkiner, & Capraro, 2008). Often times teachers will utilize new technologies in the same manner as they did the old technology. This means that those teachers who are struggling would treat interactive whiteboards simply as an overhead projector or non-interactive whiteboard. Therefore academic leaders need to provide training to teachers on how to successfully incorporate interactive whiteboards into the classroom and how to create and implement interactive lessons and activities. Simply providing the technology is not enough to guarantee increases in student achievement and motivation.

More research into different ways to incorporate interactive whiteboards into the classroom needs to be undertaken. The development of research-based resources designed specifically for interactive whiteboards would greatly enhance both learning and instruction. It would be interesting to explore whether utilizing interactive whiteboards could play a role in increasing teacher expectations, student expectations, and state and national standards. Another step to take would be to further research on the different uses and effects of multimedia in the interactive whiteboard classroom.
The presence of interactive whiteboards in the classroom is not enough to increase student achievement and motivation. Educators need to accept a new pedagogy regarding the roles of teachers and students. Teachers should serve as a facilitator while students take control of their own learning. The highest degrees of interactivity between the students and the interactive whiteboard result in the best quality of learning. The interactive whiteboard is an instructional tool capable of capturing and holding a student’s attention, bringing excitement to the classroom, and inevitably increasing the amount of high quality learning that can occur.
References


### Appendix A

Tables and Figures

Table 1

*Mad Minute Multiplication Worksheet 1 Results*

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Table 2

_Mad Minute Multiplication Worksheet 2 Results_

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*Mad Minute Multiplication Worksheet 3 Results*

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*Mad Minute Multiplication Worksheet 4 Results*

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Table 5

*Ticket Out Worksheet 1 Results out of 4 Points*

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Table 9

*Multiple Choice Unit Assessment Results out of 100%*

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Table 10

*Short Answer Unit Assessment Results out of 4 Points*

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Figure 1: Sample Classroom A Student Response to the Ticket Out Worksheet.

Name __________________________ Date ______________

Directions: Answer the multiplication question below. Then explain with words or draw a picture to show how you know that is the right answer.

1. 8 x 3 = 24

2. Explain or show how you got your answer.

I counted on the Hundreds chart.
Figure 2: Sample Classroom B Student Response to the Ticket Out Worksheet.

Name ___________________________ Date ________________

Directions: Answer the multiplication question below. Then explain with words or draw a picture to show how you know that is the right answer.

1. \(8 \times 3 = 24\)

2. Explain or show how you got your answer.

I skipped and counted by 8 three times and got 24.
Figure 3: Sample Classroom C Student Response to the Ticket Out Worksheet.

Name __________________________ Date _______________

Directions: Answer the multiplication question below. Then explain with words or draw a picture to show how you know that is the right answer.

1. $8 \times 3 = 24$

2. Explain or show how you got your answer.
Appendix B

Sample Ticket Out

Name __________________________________________  Date __________________

Directions: Answer the multiplication question below. Then explain with words or
draw a picture to show how you know that is the right answer.

1.   4 x 5 = ________

2.   Explain or show how you got your answer.
Appendix C

Interactive Whiteboard Survey

Name ___________________________________________ Date __________________

Directions: Answer the questions below.

1. What do you like about SMART Boards?

__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________

2. What don’t you like about SMART Boards?

__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________

3. What would make the SMART Board even better?

__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
__________________________________________________________________

4. If you were the teacher, what would you use the SMART Board for?

__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
Appendix D

Mathematics Survey

Name ________________________________ Date __________________

Directions: Answer the questions below.

1. What is your favorite subject in school?

__________________________________________________________________

2. Do you think Math is easy for you or hard for you?

__________________________________________________________________

3. Do you like Math class?

__________________________________________________________________

4. What do you like about Math?

__________________________________________________________________
__________________________________________________________________
__________________________________________________________________

5. What don’t you like about Math?

__________________________________________________________________
__________________________________________________________________
__________________________________________________________________

6. What is your favorite part of using the SMART Board in Math?

__________________________________________________________________
__________________________________________________________________
__________________________________________________________________
Appendix E

Sample Mad Minute Math Worksheet

Name ___________________________________________ Date __________________

Directions: Answer as many multiplication facts as you can in 1 minute.

1. 2 x 4 = ________ 2. 3 x 1 = ________ 3. 5 x 6 = ________
4. 7 x 3 = ________ 5. 5 x 9 = ________ 6. 1 x 10 = ________
7. 2 x 5 = ________ 8. 6 x 6 = ________ 9. 3 x 7 = ________
10. 7 x 4 = ________ 11. 2 x 9 = ________ 12. 8 x 3 = ________
13. 7 x 6 = ________ 14. 4 x 9 = ________ 15. 2 x 3 = ________
16. 10 x 5 = ________ 17. 7 x 7 = ________ 18. 12 x 4 = ________
19. 6 x 8 = ________ 20. 12 x 3 = ________ 21. 2 x 2 = ________
22. 7 x 3 = ________ 23. 5 x 6 = ________ 24. 1 x 12 = ________
25. 6 x 4 = ________ 26. 11 x 5 = ________ 27. 9 x 1 = ________
28. 10 x 7 = ________ 29. 9 x 6 = ________ 30. 6 x 11 = ________
Appendix F

National Library of Virtual Manipulatives Rectangle Multiplication
Appendix G

E Manipulatives Multiplication Table

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Appendix H

Area Models for Multiplication and Division

Let's try some multi-digit multiplication problems; for example, \( 12 \times 17 \). [Note: This activity requires the Flash plugin, which you can download for free from Macromedia’s Web site. For a non-interactive version of this activity, use manipulatives, or print and cut several copies of the shapes from a PDF file.]

**Problem B1: 13 \times 12**

Drag the manipulatives on to the grid to fill the area model.

To rotate a long, hold your mouse down and press "R" once on your keypad.

**Problem B2**

a. What is the least number of pieces you would need to make a rectangle of 13 units by 17 units? How would you arrange them?
Appendix I

Sample Interactive Multiplication Game
Appendix J

Interactive Mad Minute Math

2 \times 5 = \text{ Multiplication Facts } \times 5
Appendix K

Sample Power Point Presentation of Multiplication Lesson

1. Mad Minute Math
2. Ten-Minute Math
3. SMART Board Multiplication Game
4. Introducing Counting Around the Class
5. Introducing Picture Problems
6. Daily Practice
7. Ticket Out
1:00 - 2:00

Ten Minute Math

What time is it on this clock?

If I start practicing my violin at this time and practice for 35 minutes, what time will it be when I finish practicing?
1:00 - 2:00

Introducing Counting Around the Class

Today we are going to learn a new Ten-Minute Math activity. In this activity we'll count by some number and each of you will take a turn. We are going to start today with a pattern you know, counting by 2s. The first person says “two,” the next person says “four,” the next says “six,” and so on. But before we start counting, think about what number the last person will say. Try to figure it out without actually doing the counting. I’ll take your predictions after you’ve thought for a minute.
Problems

Introducing Picture

How many points are there?

Here are six stars with 5 points each.
Introducing Picture Problems

- Here are four triangles with 3 points each.
- How many points are there?
1:00 - 2:00

Introducing Picture Problems

• In the last math lesson, we talked about the three pieces of mathematical information in a multiplication situation.

• What information did I give you in each of the problems you just solved?

• What information was missing?
### Introducing Picture Problems

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Daily Practice


2. SMART Board Multiplication Game
1:00 - 2:00

Ticket Out

$5 \times 2 = \underline{}$

Explain or show how you got your answer.
Appendix L

Unit Test Multiple Choice

Name: ___________________________________  Date: _______________________

**Math Unit 5 Test**

**Directions:** Answer the following problems. There will be problems just like this on your test.

1. Which division story fits the number sentence \( 18 \div 3 = ? \)
   
   A  Sarah has 18 bottles of water. Amy gives her 3 bottles of water. How many bottles of water does Nadine have now?
   
   B  Sarah has 18 bottles of water. She gives 3 bottles of water to Chris. How many bottles of water does Sarah still have?
   
   C  Sarah has 18 bottles of water in each paper bag. She has 3 paper bags. How many bottles of water does Sarah have?
   
   D  Sarah has 18 bottles of water. She wants to put the same number of bottles of water in each of 3 paper bags. How many bottles of water will go into each bag?

2. Each bag has 4 pieces of candy. Which should Leah use to find the total number of pieces of candy?

![Image of bags with candy]

   A  \( 5 + 4 \)
   
   B  \( 5 - 4 \)
   
   C  \( 5 + 5 + 5 + 5 + 5 \)
   
   D  \( 4 \times 5 \)
3. What two factors could Ashley write to get a product of 64?

   _____ x _____ = 64

   A 8 x 8  
   B 8 x 6  
   C 6 x 5  
   D 8 x 9  

4. What number is missing? 2 x _____ = 14  or  14 ÷ _____ = 2

   A 6  
   B 7  
   C 8  
   D 9  

5. There are 5 rows of 3 bushes. How many bushes are there in all?

   A 28 bushes  
   B 15 bushes  
   C 35 bushes  
   D 25 bushes  

6. Which problem could you write for 6 x 2?

   A Alice has 6 muffins, and a friend gave her 2 more. How many muffins does she have now?  
   B Alice has 6 muffins and gave 2 away. How many muffins does she have left?  
   C Alice bought 6 bags of muffins with 2 muffins in each bag. How many muffins does she have in all?  
   D Alice put 6 muffins on 2 plates. How many muffins are on each plate?
7. Multiply.  $9 \times 4 = \underline{\hspace{1cm}}$

A 36
B 42
C 54
D 32

8. Complete the following statement: The multiples of 10 _____.

A are all odd numbers
B all end in 5
C are in a sequence of even, odd, even, odd, and so on
D all end in 0

9. If you know that $5 \times 4 = 20$, which division fact do you know?

A $24 \div 6 = 4$
B $35 \div 7 = 5$
C $20 \div 4 = 5$
D $56 \div 8 = 7$

10. Which problem can be solved by using division?

A A dog has 4 legs. How many legs do 5 dogs have?
B Today is January 11. What will the date be in 5 days?
C Jenny had $18. She spent $6. How much money does Mel have left?
D Mr. Smith has 24 students. How many groups of 4 can he make?
11. What is the next multiple of 7 in this list? 7, 14, 21, 28, 35, 42, ______
   A  43
   B  46
   C  49
   D  50

12. Peggy is making arrays. She found that for the number 17, she could only make a 1 x 17 array and a 17 x 1 array. What kind of number is 17?
   A  square
   B  prime
   C  ordinal
   D  even

13. Multiply. 8 x 8 = _____
   A  64
   B  72
   C  62
   D  49

14. There are 12 crayons in a box. Mrs. Velez bought 4 boxes for the Art Club to use. How many crayons did Mrs. Velez buy in all?
   A  36 crayons
   B  44 crayons
   C  48 crayons
   D  50 crayons
15. Which of the following does not mean the same thing as $3 \div 21$
A  $3 \div 21$
B  $21 \div 3$
C  How many 3s are in 21?
D  21 divided by 3

16. The students in Miss Harvey’s class counted by 3s. Which number was NOT said?
A  9
B  21
C  20
D  12

17. Which array matches $5 \times 4 = 20$?
A  

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18. Bill starts his Spelling homework at 5:20 pm. He finished in 25 minutes. What time was it when Bill finished his Spelling homework?

A 5:30
B 5:45
C 6:00
D 5:50

19. Use the array to help you complete the equation. $3 \times \underline{ \phantom{10} } = 48$

A 16
B 14
C 10
D 20

20. Shelly has 24 pencils. She wants to place the same number of pencils on 6 desks. How many pencils should Shelly place on each desk?

A 5
B 6
C 4
D 8
21. Each box contains 5 candles. Which should Mike NOT use to find the total number of candles?

A  5 x 4  
B  5 + 5 + 5 + 5  
C  5 + 4  
D  5, 10, 15, 20

22. The students in Mrs. Stein’s class counted by 8s. Which equation represents 5 people counting by 8s?

A  10 x 8 = 80  
B  5 x 4 = 20  
C  8 + 5 = 13  
D  8 x 5 = 40
Appendix M

Unit Test Short Answer

Name __________________________________ Date ___________

Unit 5 Session 4.7

End-of-Unit Assessment

Solve the problems and show your solutions. Write equations that represent the problems.

Problem 1

Insects have 6 legs.

A. How many legs are on 3 insects?

B. How many legs are on 6 insects?

Problem 2

Keisha’s father baked 36 muffins for the third-grade bake sale. Keisha put the muffins in bags. She put 4 muffins in each bag. How many bags of muffins did she have for the bake sale?
Dear Parents,

We have reached our math unit on multiplication! Students will need to know how to multiply for the New York State math test that is given this March. There is typically two or three questions involving multiplication on the test. Usually they are at the lower end of the times table – such as 3 x 4 or 4 x 5. In class we will be discussing and utilizing many different ways of looking at multiplication. We have started looking at it as repeated addition. For example, 3 x 4 can be solved by adding 3 four times – 3 + 3 + 3 + 3. We will also look at it as groups. 3 x 4 is the same as having 3 groups of 4 items. I also have a fun multiplication rap/song that we will be learning in class to help students recall their facts to music!

It is also important that students are able to quickly recall multiplication facts. Knowledge of the basic multiplication facts and the ability to quickly recall the answers will help the students once they get to more advanced levels of math. Because of this, students will be asked to work on memorizing their math facts at home. Cards with each of the times tables are being sent home with the students. Each day at the beginning of math class we will take a mini quiz on multiplication facts. The quizzes won’t be graded. They are just a way to keep students practicing their multiplication facts. We will start out with the 1s times table and work our way up to the 12s times table. We will then review the multiplication facts for the rest of the year.

As the students work on learning their multiplication facts, there will be less and less facts for them to “memorize.” This is because multiplication facts can be reversed. For example, once they know 2 x 8 = 16, they also know 8 x 2 = 16. By the time they get to the 12s times table they should already know up to 12 x 11. Please try to have your child practice their multiplication facts everyday. It will really benefit them in the future!

Attached to this letter is a list of Internet resources that we will be utilizing in class. These resources can also be accessed through your home computer. Please feel free to let your child practice his/her multiplication facts utilizing these resources!

Thanks!
Diane Taylor
Multiplication Resources Online!!!

Students can utilize a Multiplication Chart to help them study and test their multiplication facts. [http://www.eduplace.com/kids/mw/manip/mn_3.html](http://www.eduplace.com/kids/mw/manip/mn_3.html)

This website explores the area model of multiplication. Students utilize squares, rectangles, and base 10 blocks to discover their multiplication facts. [http://www.learner.org/courses/learningmath/number/session4/part_b/index.html](http://www.learner.org/courses/learningmath/number/session4/part_b/index.html)

The National Library of Virtual Manipulatives

Students can play interactive games that require them to utilize their multiplication facts to advance to the next level. [http://www.multiplication.com/interactive_games.htm](http://www.multiplication.com/interactive_games.htm)

This website tests students on their multiplication facts. Students are given 1 minute to answer as many facts as they can correctly. [http://www.oswego.org/ocsd-web/games/Mathmagician/mathsmulti.html](http://www.oswego.org/ocsd-web/games/Mathmagician/mathsmulti.html)
### Appendix O

**Rubric for the Ticket Outs**

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<td>The answer is correct. One of the following multiplication strategies was successfully utilized: repeated addition, grouping, or arrays.</td>
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<tr>
<td>3</td>
<td>The answer is correct. However, the explanation or strategy is lacking. The student either used a Hundreds Chart or counted on his/her fingers to get to the answer.</td>
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<tr>
<td>2</td>
<td>The answer is correct. However, the student did not provide an explanation or demonstrate a strategy utilized. OR The answer is not correct. The explanation or strategy is lacking. The student either used a Hundreds Chart or counted on his/her fingers to get to the wrong answer.</td>
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<tr>
<td>1</td>
<td>The answer is not correct. The student did not provide an explanation or demonstrate a strategy utilized.</td>
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Appendix P

Scott Foreman Math Investigations Unit 5 Session 3.1 Lesson

**SESSION 3.1**

**Arranging Chairs**

**Math Focus Points**
- Using arrays to model multiplication situations
- Using arrays to find factors of 2-digit numbers up to 50

**Today's Plan**

1. **Introducing Arranging Chairs**
   - 20 MIN
   - CLASS
   - INDIVIDUALS

2. **Arranging Chairs**
   - 40 MIN
   - PAIRS

**SESSION FOLLOW-UP**

3. **Daily Practice**

**Vocabulary**
- dimension

**Materials**
- M14; T62
- Connecting cubes
- M14; M15–M16
- Number cards for Arranging Chairs; connecting cubes; unlined colored paper; scissors; glue sticks
- Student Activity Book, p. 26
- Student Math Handbook, pp. 45, 46

*See Materials to Prepare, p. 81.

**Ten-Minute Math**

**What Time Is It?** Write 2:12 on the board and have students show the time on their clocks.

- How did you know where to put the small hand? How about the big hand? How many minutes is it past 2:00? What two five-minute interval times is it in between? (2:10 and 2:12)

Ask additional similar questions using these times: 10:03, 3:36, and 11:17.
ACTIVITY 1

Introducing Arranging Chairs

Begin this session by placing 12 cubes on the overhead projector.

Here’s a problem called “Arranging Chairs.” Imagine that these 12 cubes are chairs and that you need to arrange them in straight rows for an audience to watch a class play. You want to arrange the chairs so that there will be the same number in every row with no chairs left over. How many different ways could you do this? How many chairs would be in each row? How many rows would there be? Try different ways to arrange the chairs, even if some of the ways don’t seem very good for watching a class play.

Give students time to make as many different arrangements as they can, using their 12 cubes. When students have finished, ask them to describe their arrays.

How many rows are in the arrangement you made? How many chairs are in each row?

Discuss two possible arrangements with the class. As you do so, model the use of the words dimension and by.

[Jung] arranged her chairs in two rows with six chairs in each row. I am going to draw this as a rectangle. Each square stands for 1 chair, so two rows of six squares stand for [Jung]’s two rows of six chairs. The dimensions of her rectangle are 2 by 6. [Benjamin] made three rows with four chairs in each row. What are the dimensions of his rectangle?
Now show all of the possible arrangements by drawing and labeling them on Half-Inch Grid Paper (T62), on large graph paper, or on the board. List the multiplication equations that describe each rectangle underneath. Explain that each set of dimensions is a pair of factors for that number.

### Different Ways to Make 12

1. $12 = 1 \times 12$
2. $12 = 12 \times 1$
3. $12 = 2 \times 6$
4. $12 = 6 \times 2$
5. $12 = 3 \times 4$
6. $12 = 4 \times 3$

### Arranging Chairs

Give each pair of students two of the number cards you prepared before the session. Make sure that at least two pairs of students work on the same number so that they can compare their work.

Each pair of students should use cubes to find all possible arrays for one of their numbers and draw the arrays they find on Half-Inch Grid Paper (M14). Students should then cut out all the arrays they found for their number, glue them onto a piece of colored paper, and write the
title “Ways to Arrange [their number] Chairs.” They should label the
dimensions of each array and list the dimensions underneath, following
the directions on Arranging Chairs (M15–M16). Pairs who are working
on the same number can meet together to compare their answers.
Students follow the same procedure for their second number.

As students work, connect the pairs of dimensions for their arrays to
factors. For example, when students are listing the dimensions for 18,
you may say:

I see you found all of the pairs that multiply to 18.

As students complete their arrangements, hang their posters in a
classroom display. Tell students to look at all of the posters when they
have finished their work and to think about what they notice.

**ONGOING ASSESSMENT: Observing Students at Work**

Through building arrays, students find the factors of given numbers to 30.

- **How do students find the arrangements that work?** What
  knowledge of equal groups do they have? For example, do they
  know that they can make two rows for any even number? Are there
  other multiplication combinations that they know?

- **Do students recognize that, if they can make an arrangement
  with two rows of a number, then they can also make that number
  of rows of two?** In other words, do they know that if they can make a
  $2 \times 8$ array, they can also make an $8 \times 2$ array?

- **Do they use one arrangement to figure out others, or do they
  randomly move the cubes around until they find a new
  arrangement?**

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**Algebra Note**

**Commutative Property** Students may notice
that some of the factor pairs are reversals of each
other; that is, if $3 \times 4$ is on the list, so is $4 \times 3$.
Students are noticing examples of the commutative
property. When students comment on this
property, ask why they think these reversals occur.
Is the same thing true with other pairs of factors?
Encourage students to examine their models to see
why multiplication has this property. For more
information, see Algebra Connections in This Unit
on page 16.
DIFFERENTIATION: Supporting the Range of Learners

**Intervention**
Questioning students who are arranging cubes randomly will help them slow down and think through their approach.

- I see that you made an arrangement for your number with four rows. Look at what you have. Is there any way that you can put some rows together or split them up in order to make a different arrangement? Can you make a rectangle for your number with two rows?
- You made a rectangle of four rows with six in each row. Can you make a rectangle with six rows? How many would be in each row then?
- Think about 24 for a minute. What are some ways that you might be able to split up 24?

**Extension**
Some students may be able to work with larger numbers. Ask these students to arrange 64, 72, or 128 chairs.

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**SESSION FOLLOW-UP**

**Daily Practice**
For ongoing review, have students complete *Student Activity Book* page 26.

**Student Math Handbook**
Students and families may use *Student Math Handbook* pages 45, 46 for reference and review. See pages 176–181 in the back of this unit.
Appendix Q

Sample Scott Foresman Math Investigations Worksheet

Name ____________________________ Date ________________

Assessment: *Counting Around the Class*

Solve these problems and show your solutions.

**Problem 1**

Kathryn’s class is counting around by 3s.
What number does the ninth student say?

**Problem 2**

The students continue counting around.
What number does the eleventh student say?

Sessions 2.5, 2.6 Unit 5
Appendix R

Sample Group B Supplementary Material

7x3=  
8x2=  
6x4=  
4x5=  
8x4=  
3x6=  
2x7=  
7x5=  
3x8=  
6x6=  
2x5=  
5x3=  

Name ____________________________