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Interactive Technology and Gaming to Enhance Understanding in Mathematics

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Abstract

Integrating math and technology has been shown to enhance the educational future of children today. The integration of interactive technology through the use of electronic whiteboards and gaming to enhance student understanding in mathematics was investigated. High school students (N~80) reviewed content through an electronic whiteboard and gaming. It was shown that gaming through the use of electronic whiteboards increased student achievement in mathematics by ensuring a deeper understanding of the material presented.

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Abstract

Integrating math and technology has been shown to enhance the educational future of children today. The integration of interactive technology through the use of electronic whiteboards and gaming to enhance student understanding in mathematics was investigated. High school students (N=80) reviewed content through an electronic whiteboard and gaming. It was shown that gaming through the use of electronic whiteboards increased student achievement in mathematics by ensuring a deeper understanding of the material presented.

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The education system is continuously examined for improvement and one of the areas of concern that arise is how math is being taught in classrooms. Methods of teaching mathematics for a deeper understanding are constantly discussed and implemented in an attempt to keep up with the ever changing needs of students. Research has indicated that the enrichment of math courses gives a firm base in the approach to algebraic studies. One study suggested that "algebra is the gate keeper course to advanced study in both mathematics and science" (Spielhagen, 2006, p. 31). This suggests that early access to algebra may lead to positive math attainment, higher performance, and more math courses taken. Advancements in technology are being used as one method, to aid in achievement of an early firm base in mathematics.

Technology has become increasingly integrated into the modern classroom. An educational program goal of the No Child Left Behind Act was to improve student academic achievement through the use of technology (Judge, 2005). It was recommended that technology be integrated into the learning environment. In addition to technology being developed into a necessary tool in current society, "math should [also] be treated as a necessary tool for problem solving rather than a separate abstract and irrelevant subject" (Stone, 2008, p. 791). The use of technology in mathematics classrooms attempts to address both developments. There is a growing need for literacy in math and technology has been found to increase access and expand upon higher level math literacy skills (Shanahan, 2008).

One aspect of technology that has been introduced into schools is that of the interactive whiteboard. An interactive whiteboard is a large touch-sensitive board which is connected to a digital projector and a computer which controls it (Smith, 2005). The

board is generally placed at the front of the classroom where the chalkboard or marker board was traditionally located. Interactive whiteboards in the classroom were designed as a tool to enhance teaching as well as a tool to support learning (Smith, 2005). Due to the fact that this is a new item of technology, it has been piloted with few academic sources to support their use and the literature has been slow to emerge examining the benefits of this innovative teaching tool.

The use of games has also been a common method of teaching in the classroom. Games have been used for instruction, review, re-teaching and practice for concepts and skills in math classrooms. Gaming software that has been considered fun was developed for educational use and shown to be linked to academic achievement (Judge, 2005). Gaming techniques were motivating for teachers and students for use in the classroom because of the high level of engagement involved. Interactive games have been suggested to be a successful resource for learning based on enjoyment levels and responses that indicated more accurate decision making (Smith, 2005).

Integrating math and technology enhances the educational future of children today. As interactive whiteboards become more common it is important to examine their effectiveness within education. Games have been continually integrated into the common classroom as a tool for engagement and enhanced learning. This study will investigate if the integration of interactive technology through the use of electronic whiteboards and gaming may enhance student understanding in mathematics.

Literature Review

Methods and pedagogy involving technology has been investigated for benefits in education. The literature discusses the idea that there have been many strengths associated with technology and interactive whiteboards within instruction. Additionally, it has been reported that interactive technology has been shown to be efficient, versatile and motivating. The research discusses the aspects of technology that benefit students, teachers and the education community. However, it is important for teachers to have training and support for the successful implementation of whiteboards. The following also includes evidence and methods for successful use of the technology. Throughout the years gaming has been used as an educational tool and research has been done to show the benefits. Integration of gaming and interactive technology leads to the complex learning that is important for students to access a deeper understanding of mathematics.

Methods of effective instruction have been constantly reviewed so that teachers could implement the best ways to provide a deeper understanding of information for students. For instance, effectiveness of instruction depends on a rich, realistic source of information and guidance by an effective teacher (Bottage, 2003). A study conducted on the effects of video-based and applied problems that dealt with providing rich and realistic sources on procedural math skills. It was found that the most effective use of these rich and realistic sources of information was a combination of approaches from an effective teacher. Teachers who used engaging realistic problems and direct instruction were able to develop skills that helped to solve meaningful problems. The National Council of Teachers of Mathematics stated that all students should have opportunities to solve meaningful and complex math problems. The quality of the opportunities provided should be judged by the effects on the students.

Additionally, a motivating problem context was found to be important to help students practice skills. Motivating contexts included career and technical education that aided students in their employment future. Career and technical education courses demonstrated to students that rigorous math is highly relevant (Stone, 2008).

Explicit math lessons should be incorporated into curriculum for all courses when they naturally occur. Career and technical education studies suggested that math taught in courses should arise directly out of occupational content. The math topics should not be forced into the curriculum. The study showed that incorporating math into courses where they naturally occur positively impacted student's math performances on traditional summative assessments. Participants from the study indicated that math in career and technical education works and is a clear example of where appropriate technology integration occurred (Stone, 2008).

Learning styles and abilities differ among students. Students of all ability levels have been assessed in order to best implement methods to meet their individual learning needs. Students with disabilities tend to fall behind, and have not been able to easily catch up to classmates who achieve at an average level. These delays lead the students to drop out of school (Bottage, 2003). Incorporating natural occurring math with technology in career and technical education has been shown to help low achieving students increase the skills needed for post-high school education and the work force (Stone, 2008).

Methods to support students with disabilities also have been revealed to include computer based instruction. Mechling (2008) suggested the use of computers as a potentially useful and effective method of instructing students with disabilities. Other

studies have shown that integrated technology has been demonstrated as a developmentally appropriate practice (Judge, 2005). Additionally, Computer Assisted Instruction was indicated as an effective method in training math skills regardless of the teaching approach used (Vogel, 2006).

Technology has been used to create meaningful learning activities that engage students in complex and authentic tasks. Many times technology was used to utilize project based learning and support constructivist theory (Mouza, 2008). Instead of using drill and practice methods, teachers incorporated technology to allow students to investigate and build upon existing knowledge.

In 2000, a study was conducted that included a statistical analysis of the relationship between technology and student achievement. PISA, the Programme for International Student Assessment found evidence that the use of technology can have a significant positive effect on the learning needs of students. The performance of students was aided by the use of computers through email, web pages and educational software. The study was limited in that it showed the presence of technology was not, by itself, related to student achievement. The use of technology may have helped or hindered academic learning depending on the nature of its use (Bielefeldt, 2005). Technology enables diverse approaches to teaching and learning that could not be achieved by traditional methods such as the use of a text book (Li, 2007).

The use of technology such as laptops was shown to have supported learning. A study by Mouza, (2008) showed that students had an increase in motivation and persistence in doing school work. Interactions increased between peers and teachers due to the laptop technology. Students were empowered to be responsible for their own

learning and as a result their confidence increased in their academic ability. Academic improvements were seen in both writing and math. The students perceived computers to be important tools because they served as an information resource that were useful for future employment as well as assisting in the learning process. In addition to supporting academic processes, the increased enjoyment from the use of the laptops positively influenced the student's attitudes toward school (Mouza, 2008).

Information and communication technologies have been used successfully for administration, communication, and research as well as teaching and learning. These technologies were able to serve a more diverse student body in various social, demographic and geographical bases. Global competitiveness in education is constantly being enhanced as information and communication technology is updated and incorporated. There has been a move to try different approaches to enhance teaching and to move away from didactic methods that were not effective. For example, incorporation of the use of the world wide web has been shown to develop a more student-centered approach to learning. It has been suggested that information and communication technology increased efficiency, access and flexibility in teaching methods (Eynon, 2008).

Computers can be used for CD-ROMs in order to present interesting problems in a video format. A study was conducted on video-based and applied problems in math which engaged students to solve tasks on a CD-ROM. Through the video-based presentation students could have immediate access to problems without having to decode and comprehend word based problems. It was found that low achieving students figured out comparable applications by making connections to the video problems. The video

problems eliminated reading long passages and allowed students to focus on the needed components. The study suggested that video presentations increased student motivation as well as improved student achievement. Video-based instruction lead to integration and students were able to apply knowledge on transfer tasks (Bottage, 2003).

Through the technology of the interactive whiteboard, information is presented in an interactive way which may meet the needs of students with different learning styles. Interactive methods shown to be part of the interactive whiteboard were sound, video, animation and enrichment of text (Mechling, 2008). Pictures allow children to see relationships in content (Vogel, 2006). The study of the effects of Smart Board Technology implied that stimulating visual images enhances student recall. The study also showed that the interactive whiteboards lent themselves to independent work as well as group work. The whiteboards facilitated whole class discussions and led to the sharing of ideas and the generation of theories (Smith, 2005).

Overall findings of a study on the impact of interactive whiteboards on classroom interactions implied that the new technology influenced how students worked together. The interactive whiteboard lessons had more whole class teachings and less group work than non interactive whiteboard lessons. Within these whole group lessons there were more open ended questions as well as answers and evaluations from the students. The frequency of student answers was higher in the interactive whiteboard lessons than in the non whiteboard lessons (Smith, 2006).

According to Smith (2005) the advantages of the use of computers and interactive whiteboards include quality presentations that make use of large visual images and have a modern contemporary feel. Through these methods teachers attempted to “satisfy the

expectations of pupils already immersed in a world of media images"(Smith, 2005, p.96). When used properly and appropriately, interactive technology enhanced student's cognitive and social abilities (Judge, 2005). Vogel (2006) stated that the benefits of the use of computers and virtual reality tools such as whiteboards included a 3-D lifelike experience and individual control of the experiences. These strategies aided in the comprehension of complex ideas and skills. Teachers are able to access a wide range of materials through interactive whiteboards. Students and teachers were both able to manipulate the board (Smith, 2005). Additional benefits include student motivation, attention and increased time on task (Mechling, 2008).

Literacy

The National Council of Teachers of Mathematics recommended an increase in math literacy for all students (Spielhagen, 2006). Literacy has been connected to health maintenance, academic success and positive contributions to society. There is rising correlation between education level and income. Shanahan (2008) found that there is a clear need for discipline teachers to have explicit literacy standards.

Additionally these teachers needed resources to allow them to teach in various situations and classroom contexts. The internet was found to be one source for resources that were used to increase literacy. Eynon (2008) found high value in the range of resources that the internet could provide access to. An additional approach to supporting literacy was shown to be computer access for achievement in school as well as in life. As the ratio of computers per child has increased, the academic achievement of students has been shown to increase (Judge, 2005).

Teachers have developed literacy instruction to included technology tools. These technology tools included computer hardware and software which challenged student learning. Higher level thinking and problem solving were accessed through the computer technologies which were shown to aid in improvement of literacy (Moore-Hart, 2008).

Implementation and Support

When new programs such as the use of laptops, information and communication technology and interactive whiteboards were implemented there were factors that contributed to their success. These factors included teacher and student views about the new method. A study was conducted that critically examined teacher and student views about technology integration in schools. The study found that student and teacher beliefs about technology may affect their adoption.

Additionally administrative understanding of technology affects school policies. Administrators, along with students and teachers, are stakeholders in the success of integrated technology. The interactions of those who had a stake in the success of the technology carried out tasks that enabled the new programs to function (Li, 2007). When the administrators understood and promoted the integration techniques the policies of the school were more likely to succeed. Information and communication technology was enhanced with improvements in institutional support. It was found that institutions and staff examine the contexts within which the technologies are used. The understanding of use motivations and these contexts lead to the success of the programs (Eynon, 2008).

Adamy (2005) also supported the idea that two important factors are administrative support as well has having expectations of and incentives for the use of new technology. It was implied that the organizational context of implementation plays

an important role in the integration of technology. First, there needs to be availability and use of resources. Second, educators must have positive relationships with the key technology experts. Finally, teacher attitudes toward the use of technology play an important role in the successful implementation of a new program (Adamy, 2005). Another study was conducted on using Web-based computer games. It was claimed that "teacher's openness toward student-directed inquiry is a key to success in using this medium in the classroom" (McDonald, 2003, p. 470).

Efficiency

Attributes of interactive whiteboards include aspects of increasing efficiency in the classroom. Smith (2005) critically examined the use of whiteboards and found that there was a reduction of planning time as a result of being able to save, share and reuse materials. Therefore the teacher does not have to spend as much time during the day planning and setting up resources. Results of the investment of time and effort of planning the interactive white board lessons were also reflected in student work. A range of needs was able to be met within the carefully planned lessons which support the success of the students.

Due to the interactive whiteboards being connected to computers, the sharing of resources was more abundant through the use of a network or intranet. Appropriate resources could be accessed and used for individual student needs (Smith, 2005). 73% of students found the use of technology efficient for learning. They first found that it made for easy access to information and research. Second, they stated that it made learning easier (Li, 2007). The touch sensitive aspect of the whiteboards made them more efficient and lead to a professional delivery.

During the math lessons there was a seamless flow from one point to the next as well as smooth transition between the activities within the lesson. Additionally there was a quickening of the lesson pace. Students reported that the lessons were paced faster which made them more fun and exciting. Research by Smith (2006) also supported that interactive whiteboards increased the pace of the lessons. The boards also allowed teachers to face the class and spend more time focusing on the needs of the pupils which aided in transition. The supplementary use of electronic tablets allowed teachers to leave the front of the room and students to set their own pace.

Versatility

Interactive whiteboard technology was found to be versatile. It could be used in multiple content areas as well as diverse activities. The whiteboards were able to be used by all age ranges from nursery to higher education. Students may also have flexible options to use distance learning when using technology connected to the whiteboards.

During whiteboard lessons teachers were able to quickly flip back to review material. This was found to help lower ability and special needs students. Students who would not normally choose to do computer work were able to work on the interactive whiteboards. Activities could be accomplished on the whiteboard without the use of fine motor skills needed for a computer and mouse (Smith, 2005).

Motivation

Students within the secondary grades have shown a waning interest of participation in their education. As students progressed to higher grades, their motivation declined due to factors such as difficulty level or lack of interest. Use of technology in a meaningful manner helped teachers increase or sustain motivation within their students.

Increased motivation, engagement and extension were found to be a result of enthusiasm for technology such as laptops. The students were allowed to learn concepts in a differentiated manner. Laptops and technology also allowed them to direct their own learning (Mouza, 2008).

Views of students play a role in their motivation to succeed. A study conducted on student and teacher views toward technology found that 87.3 % of students liked to use technology and believed that it would be effective in learning. It was also found that technology increased confidence and allowed students to go beyond basic tasks (Li, 2007).

When interactive whiteboards were used as a tool to support learning, students thought lessons to be more enjoyable and interesting. When lessons were more enjoyable and interesting to students there was an increase in positive attention and behavior. Students enjoyed interacting physically with the board by manipulating text and images (Smith, 2005). It may have been interpreted that these interactions were a form of entertainment with elements of play. Play has been found to be necessary for motivation in students. Play along with interaction with computers was found to amplify motivation (Vogel, 2006).

Training

When new teaching strategies are introduced, there is a variation on how to implement them. Professional development supports major elements of a successful school such as continued growth, organizational commitment, quality, resources, instruction and measures of accountability. A consistent and determined effort for

improvement is required every year (Thompson, 2007). Several factors contribute to whether or not teachers receive a formal training for a new strategy such as the use of technology and the support of administration.

A teacher's willingness to integrate technology was shown to be connected with their comfort level in using it (Li, 2007). If a teacher did not feel comfortable in a situation or with a strategy they tended to use methods that they were used to. Teachers who were well prepared and valued the use of technology could use elements such as laptops to enable student to engage in powerful learning experiences (Mouza, 2008). Trained teachers who were more prepared felt more comfortable with the technology and this lead to a willingness to utilize it.

By examining the current status of training and by planning a direction, schools could close gaps, overcome barriers and identify staff needs. Thompson (2007) conducted a study on the development of staff training in virtual high schools. It was found that once needs were identified then professional development could begin. Schools first needed to build a community among themselves before they could engage the students. In order for technology to be used effectively, professional development and training were suggested as important aspects of the process (Judge, 2005).

It was stated by Smith (2005), that a need was found for adequate training in order to use interactive whiteboards to their full potential. These opportunities included a mixed mode of delivery. In the virtual school study, both in person and virtual methods of training were used. The study on training in virtual schools found that "a well trained staff is critical for sustaining programs and needs of students" (Thompson, 2007, p. 2).

The success of the virtual school showed that a school's commitment to its teaching staff needs to be constant and unending.

Though there are several methods of training, teachers are not receiving opportunities to prepare themselves to use technology in their teaching (Judge, 2005). When a teacher did not receive an adequate amount of training, there was found to be negative effects on the use of new technology. With a lack of practical and methodological training, teachers became frustrated and their progress was impeded (Smith, 2005). Teachers who did receive sufficient training on interactive whiteboards were then able to model their skills for the students they taught (Smith, 2005). Students benefited from the training of teachers on interactive whiteboards. Students respond positively to a clear explanation of how to use a new piece of equipment.

Additionally, training lead to transformations or the ability of teachers to move from cycle time to real time. Traditionally, teachers, as well as students, needed cycle time to go from concept to delivery. When training was received for the interactive whiteboards, teachers were able to go back and teach immediately using what they learned (Thompson, 2007).

The need was found for explicit monitoring of implementation as well as rewards for implementation of the initiatives. Teachers, who had their progress continuously monitored in combination with using instructional management systems, were able to increase their student's math performance (Ysseldyke, 2007).

Gaming

Technology lends itself to many new modes of presentation. One strategy that is increasingly more utilized is that of gaming. Students emphasized that the use of games

or other entertaining methods to present and expand upon topics were useful (Li, 2007). These methods of presentation included virtual reality, simulation, internet and games. Interactive whiteboards support the concept of games and alternate presentations to enhance understanding in that they possess tools that the teacher needs to present these methods.

The concept of game use as a learning method has been examined for its academic advantages. It has been found that a learning environment could be built on the educational properties of games. Some of the characteristics of educational games included promotion of challenges, co-operation, and engagement, the development of problem solving strategies and being user-centered. These characteristics aid in developing students who achieve at a lower level. Students who struggle with academics were shown to benefit more from the use of games than the more advanced students (Gros, 2007).

Additionally, it was found that the role of the teacher is very important as to how the game is implemented so that it becomes a part of the learning process (Gros, 2007). Teachers with little experience with the use of video games feel insecure and need a lot of support. When teachers receive support of the use of technology and integration of gaming it lead to increased success (Gros, 2007).

Vogal (2005) conducted a study that assessed using virtual reality with and without gaming attributes for academic achievement. It was expressed that "Learning games may represent an effective way of delivering simulation to a wider population of learners than currently have access to such systems" (Vogal, 2005, p. 106). The virtual reality program was shown to lead to increased understanding of complex math concepts.

Virtual reality illustrated that computer assisted instruction increased motivation through play, interactivity and challenge. Play allowed for more efficient learning and increased cognition of material. Students were also able to gain feedback through rewards and scores by using the virtual reality programming to enhance their learning. The points and rewards of the feedback resulted in faster and more efficient learning. These virtual reality programs illustrated that the use of games could increase motivation. They encouraged engagement and practice.

Another aspect of technology use for achievement was that of web-based computer games using a mixed method of inquiry. Web-based games were used to review a large amount of information. It was found that the web-based games were an effective and motivating way to review. Through these games students were more engaged and they were able to process information more deeply. The games inspired students to take ownership of the activities which helped them to develop a deeper understanding. Increased discussions among groups about topics were prompted by the games as well. The web games facilitated student centered learning. Misconceptions were clearly revealed through web use and students actively sought additional information. There was continual motivation and requests from the students to continue the web based activity. The study indicated that this willingness lead to more time spent studying and enabled a deeper understanding. Additionally, web-based games were practical for the classroom in that they could be used anytime including at home (McDonald, 2003).

Ke (2007) conducted a study that investigated the effects of game playing on fifth grade math performance and attitude. The game study used a state standards based math

exam to check performance and an attitude inventory for math attitudes. A combination of computer games and cooperative learning were considered to improve math education. Also found was that game playing was more effective than drills in promoting math performance. Additionally, cooperative game playing promoted a positive math attitude.

Mathematical reasoning through use of games was found to have occurred in a study conducted by Houssart (2008). The computer games study that was conducted examined developing mathematical reasoning with the use of games. Students were shown to have made conjectures, modifications, and justifications after the use of the computer math games. These effects were due to the use of game strategies with the computer as an opponent along with effective collaboration. Opportunities were provided in the games to use math language which included precision use of math language. This use of math language was also encouraged to develop exploratory talk among students. Through the games practice was provided as students attempted more complex tasks while trying to beat the computer. Students were also offered opportunities through the games to practice without fear of making errors which increased motivation (Houssart, 2008).

Complex Learning

More advanced problem sets require higher order thinking. Bloom's taxonomy shows that more advanced products are needed to reach the upper levels of thinking. Rice (2007) found that drill and kill activities had some value on lower level learning. Students weak in math especially gained from these activities due to the need for time to practice math skills. It was supported that teachers and students enjoyed the experience of a math drill game which encouraged higher motivation and the greater work-through

of problems. As problem sets advanced, a virtual interactive environment included products to encourage higher order thinking. The term interactive indicates that participation requires multiple user interactions. Participation in interactions such as reading, clicking, keyboard input, speech and hearing. The environment or the context that the game takes place in has also been shown to be elemental (Rice, 2007). That is how the teacher presents the purpose as well as incorporates the tools needed to be successful.

Additionally, the complex nature of advanced three dimensional environments offers multiple opportunities for students to engage in higher order thinking. Advanced computer games engage learners in two main cognitive processes. Competence and expertise are necessary for successful computer games which force users to work hard toward conclusions offering opportunities for accomplishment. Cognitive virtual interactive environments provide sufficient opportunities for complex interactions, making them suitable environments within which higher order learning may occur (Rice, 2007). It was also implied that adventure and simulation games provide complex learning environments that aid in meaningful learning. Through the use of games that utilize experimentation and play the construction of relevant knowledge can occur (Gros, 2007).

Higher order components that were contained within computer games included a user which assumed a role in the game. Other components included simple to complex puzzles that required an effort to solve and simulation of complex processes that required the adjustment of variables. Finally, the gathering of information to complete elements of the game requires a more complex line of thinking (Rice, 2007).

Concerns

While using the interactive whiteboards in a classroom setting, concerns have risen. The whiteboards were not always practical in their height placement. If they were placed too low in the front of the room then students in the back of the room could not see the board. When the board was placed too high in the front of the room the top of the board could not be reached by many students. Other visual problems impeded the use of the board such as seeing the board clearly due to sunlight, colors, fonts, dust and shadows (Smith, 2005).

Teachers also found that over time the novelty of the boards began to wear off as students became accustomed to the technology. Quality interactions are limited by the teacher being in power in the front of the room. The power was removed from the students to ask and answer questions as well as evaluate understanding. Smith's (2005) analysis also found that older students such as those at the secondary level had less desire to leave their seats and go to the board. Other students had trouble manipulating the equipment. Those students who did want to actively use the boards were slowing down the pace of the lesson.

Views of teachers that pertained to the use of interactive whiteboards in the classroom included skepticism about integration. The high cost of the whiteboards hindered the implementation within many schools. Those teachers and students that had access to interactive technology had limited experience with the technology. The lack of experience lead to low confidence, limited use of whiteboards and reluctance to spend time infusing lessons and technology. Additionally, an initial amount of time is necessary in preparing the board for use as well as setting up activities to use with the

board. Concern was expressed over the amount of time needed to set up the interactive games with the advanced components necessary to be effective (Gros, 2007).

Teachers expressed that they thought the computer technology should only be used when necessary. Many times the technology is strongly encouraged to be used but there is a lack of use. Computers have been installed in many schools yet many teachers have not used them (Li, 2007). The computers are also connected to the world wide web but teachers expressed that the web should not be used just for the sake of using technology. Technology and the internet should be used appropriately in teaching and learning (Eynon, 2008).

Technology and gaming have both been evaluated extensively in the classroom. The literature shows that technology has a positive impact on the complex learning of students. Using motivating and relevant contexts along with explicit math lessons supports the diverse learning styles and abilities of students. As long as teachers have training and support the implementation of technological methods of instruction can be successful. Technological methods of instruction included computer based instruction, information and communication tools, video based presentations, and the newly implemented interactive whiteboard. Advantages of the electronic whiteboard include efficiency, versatility, increased motivation in students, and literacy development. Additionally, gaming has been supported by the research as a tool for the complex learning of students. As long as the teacher implements a game as part of the learning process, the elements of play and competiveness were found to be effective. One application of the whiteboards is that of gaming.

An environment that offers opportunities to use technology and engaging methods of education includes problem sets that require a higher order of thinking that leads to complex learning. A new addition to technology resources is that of the interactive whiteboard. As interactive whiteboards become more common it is important to examine their effectiveness within education. This current study will examine how interactive technology and gaming enhance understanding in mathematics.

Methodology

Integrating math and technology has been shown to enhance the educational future of children today. A new addition to technology resources is that of the interactive whiteboard. As interactive whiteboards become more common it is important to examine their effectiveness within education. One application of the whiteboards is that of

gaming. Games without interactive whiteboards have been continually integrated into the common classroom as a tool for engagement and enhanced learning.

The integration of interactive technology through the use of electronic whiteboards and gaming may enhance student understanding in mathematics. It is hypothesized that gaming through the use of electronic whiteboards will increase student achievement in mathematics by ensuring a deeper understanding of the material presented.

Participants

Eighty students, 33 female and 47 male, from four ninth grade algebra classes at Penfield Central School District participated in this study. The students remained in their math class for a period of forty minutes. Classes were chosen based on access to and comfort level with interactive whiteboard technology. Classes received instruction through use of the whiteboards on a regular basis. Student achievement levels varied in mathematics between and among each class. Students were familiar with both warm ups and exit tickets. The regular note routine included delivery via interactive whiteboards in conjunction with guided notes.

Materials

Gaming software was used from Pearsonnet resources. The software is connected to the textbook used by the district. The software is on a CD which is played on a laptop connected to the Smart board. There is an interactive game for each chapter in the book. The games are pre made with preferences for play modes such as number of players. The

game can be played individually, in pairs or in groups. Questions are multiple choices and each player or team must buzz in. Once the team is recognized by the teacher or the computer there is a time limit in which an answer must be given. Points are awarded for a correct answer and deducted for an incorrect answer. Gaming software has the components of level appropriate questions along with competitive aspects that the research has shown to lead to achievement.

In addition to the gaming software, warm up exercises were given at the beginning of each class (See appendix A). Exercises similar to warm up questions were given as exit tickets (See appendix B). Questions for the warm up and exit tickets were randomly assigned and chosen due to their individual properties. There is a variety in the level of difficulty of each question. Each question is a valid and reliable question in that they test what they are meant to test and have been shown to have consistent results. Several informal questions were added to the exit ticket to elicit responses about the electronic smartboards, gaming and their impact on understanding of mathematics.

Procedure

Classes were randomly chosen to be in either a control class or an experimental class. Each group was the same except that the experimental group received the independent variable manipulation. This ensured a balance of characteristics across the conditions of the independent variable manipulation. Research was conducted during unit eight in the curriculum. This unit occurs immediately prior to the midterm and includes a variety of topics such as problem solving and other related geometry topics. The review day of the unit was chosen to be used for collection of data. On this day the

classes practice the topics to ensure understanding. Topics have all been taught prior but deep understanding and enhancement is one of the goals of the class period.

Each class was given the same warm up exercises at the beginning of their specific class as a pre test (see appendix A). The warm up consisted of basic, intermediate and advanced questions on ratios, proportions, area, perimeter and problem solving. A complete answer with work shown was graded with a correct score of two points. A partially correct answer or little work shown was graded with a score of one point and an incorrect or blank answer was given a score of zero.

Two of the four classes that made of the control group then completed paper and pencil practice problems. Each student individually completed worksheets in which they practiced problems from the unit. The two experimental classes completed the interactive game practice problems. Each student of the control group worked individually on each question. In the interactive game group the students took turns to give their individual answers to the game. This ensured that each student was being an active participant. As a part of the game, points that could be earned were stated at the beginning of the question. A correct answer awarded the participant points while an incorrect answer deducted participant points.

At the conclusion of the class each student completed an exit ticket as a post test (see appendix B). The exit ticket consisted of basic, intermediate and advanced questions on ratios, proportions, area, perimeter and problem solving. A complete answer with work shown was graded with a correct score of two points. A partially correct answer or little work shown was graded with a score of one point and an incorrect or blank answer was given a score of zero.

Each class was conducted in the same manner with the exception of the how the review material was presented. Two of the class used a paper and pencil method and two of the classes used the interactive gaming method. Statistical analysis was used to determine if there was a significant difference in the scores of the pre and post exercises between the four classes.

In addition to scored assessments, researcher observations were collected. Student involvement, engagement and levels of understanding were observed by the researcher in both the control and experimental groups. Body language, facial expressions and comments by the students were recorded throughout all groups.

At the end of the formal assessment an informal questioning was also conducted in all of the classes to gain student perspectives on the use of the electronic whiteboards and gaming to enhance mathematics understanding. Two multiple choice questions were asked. The first was, when used together, the electronic whiteboard and interactive games help me to understand math, very well, somewhat or not at all. The second question included, when used together, the electronic whiteboard and interactive gaming help me to understand math, better then other methods, same as other methods, not as well as other methods. Two open ended questions were asked as well: (1) In what ways , if any, does the electronic whiteboard help you to understand math? and (2) In what ways, if any, does interactive gaming help you to understand math?

Table 1

Analysis of Variance for the Exit Ticket of the Experimental Group

Source	df	F	p

Exit Ticket	1	.736	.046

*p< .05

Results

Integrating math and technology has been shown to enhance the educational future of children today. As interactive whiteboards become more common it is important to examine their effectiveness within education. Gaming and interactive

whiteboards were evaluated as tool for engagement and enhanced learning. The integration of interactive technology through the use of electronic whiteboards and gaming was tested in order to show that understanding in mathematics may be enhanced. This was tested to show that through this method students had greater achievement through a deeper understanding of the mathematics content.

Eighty students, 33 female and 47 males, were participants from four mathematics algebra classes. Two of the classes received traditional content review instruction (control) two of the classes received content review through a game and the interactive whiteboard (experimental). All four classes completed a warm up and an exit ticket that were scored out of 12 points.

Additionally, participating researcher collected observations about the methods and student reactions. Student also answered informal questions about their views on various methods that were tested. Results are presented first for the achievement scores and then for their responses and views on the presentations. The dependent variable was the scores collected after the method presentation (exit tickets).

The warm up and exit ticket scores were entered into a one-way analysis of variance (ANOVA). The warm up ticket scores means of both the control group ($M = 6.38$, $SD = 2.503$) and the experiment groups ($M = 6.86$, $SD = 2.503$) did not vary statistically. This showed that there is no significant difference in scores of the students before the instruction methods were completed. The student's scores indicated a similar understanding of the content at this point in the unit. All students had received instruction in the unit including basic introductory lessons and assignments. Students then completed the control and experimental methods of review for the unit.

Upon completing the instruction the participants concluded with the exit ticket. As shown in table 1, the analysis of variance indicated that the experimental method significantly affected the student understanding of the content. The test showed that the experimental method was associated with significantly better results on the exit ticket than were the control method.

Observations were also collected by the researcher during the execution of the research in both the control and experimental methods. During the paper and pencil method (control) students individually completed questions and practiced the concepts that had been presented during the unit. Both constructive and unconstructive impacts were seen by the researcher. A constructive impact that was observed was that students were able to ask questions about the problems during the control method. Students also were able to work at their own pace. The researcher was able to identify areas of misconceptions with individual students through the questions that were asked by the students. Misconceptions were also recognized through incorrect responses from the students within their work.

Conversely, unconstructive impacts were observed as many of the students had a difficult time staying on task. Students would begin talking to each other about other topics and had to be redirected by the researcher. It was also observed that the students did not seem engaged by task. This was indicated by the off task discussion as well as student comments and facial expressions. Several students negatively questioned the purpose for the paper and pencil task. Other comments included the indication that they found the task boring.

During the experimental method it was observed that students were first and

foremost highly engaged. Each student was working to get a correct answer so they could earn points instead of lose them. Student's negative behavior was minimal. Redirecting seemed to be needed only due to the change in the structure of the class as opposed to a lack of interest in the method. While students answered questions individually they were encouraging of each other and on occasion offered advice if needed. After the completion of the activity students asked when they would be able to do the game again. A few of the students who tend to need a little more time to answer questions seemed to struggle somewhat with the pace of the activity.

Students were also asked several questions in reference to their views on the electronic whiteboards and interactive gaming. The majority of the students responded that when used together the technology and the gaming helped them to understand mathematics very well or somewhat. Very few of the students responded that when used together technology and gaming did not at all help them to understand math. The majority of students responded that when used together the electronic whiteboard technology and games helped them to understand mat either better than other methods or the same as other methods. None of the students responded that it did not work as well as other methods.

The researcher asked two additional open-ended questions. The first was in what ways, if any, the electronic whiteboard had helped the student to understand math. Several students responded that either it only somewhat helped or did not help them to understand math. Most students responded that it helped them in a variety of ways. One student stated that it helped them "because I can visually see the work being done." Many of the other student comments included references to how it aided them in a visual

manner. Another student response was that "it gives us another point of view about what we are learning." Some student responses indicated an increased clarity level. "It is easier to understand the concepts and it is fun to use." Student's implied that the electronic whiteboards made the content more engaging as well.

The second question was in what ways, if any, the interactive gaming had helped students to understand math. Some student responses expressed that gaming did not help them or they were unsure how it helped them. Majority of students responded that games make it more fun to learn. "Games are fun and make me want to learn." Other student responses included that "you remember games." Additionally, responses also indicated that games help to visually picture what were doing. A level of freedom was also expressed as shown by the comment "Games help me to understand math well because I am learning but I do not feel tied down." The games also included an element of challenge for the students that were seen to be helpful to the students. One student stated that "you have to figure things out rather then just doing a problem." Final comments included that the use of the whiteboard on a daily basis was beneficial to student understanding in math while a less regular use of gaming was helpful.

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Discussion

The integration of interactive technology through the use of electronic whiteboards and gaming may enhance student understanding in mathematics. It was hypothesized that gaming through the use of electronic whiteboards would increase

student achievement in mathematics by ensuring a deeper understanding of the material presented. Students in four algebra classes were divided randomly in to either a control group or an experimental group to test if electronic whiteboards and gaming enhanced the students understanding of the content. The students completed a warm up, an activity, an exit ticket and informal questioning. The researcher completed a one-way ANOVA statistical test as well as an examination of the qualitative data.

The statistical analysis showed that there were significant differences in the end result. The exit ticket scores between the control group and the experiment group indicated that the experimental method increased student understanding of the content. The results expressed that the experimental use of the electronic whiteboard was associated with significantly better results on the exit ticket than were the control method.

Observational data from the researcher also showed that the use of the electronic whiteboard and gaming was beneficial to the students. The students were more engaged in the experimental group than the control group. The higher level of engagement seemed to increase student motivation which may have aided in their understanding. Students were able to answer questions individually but encourage and aid each other when the need developed. The students who appeared to struggle the most with the activity were those who need more time to work through a problem. This could be adjusted by the teacher so that the students had the time they needed to participate.

The control method did have some benefits for the participants. Students complete tasks at different rates and the control method allowed for the differences in student work pace. Individual students were able to ask questions specific to them and individual errors and misconceptions were easier to identify. Negative aspects of the

control method included that many of the students had a difficult time staying on task. The researcher had to consistently use class time to redirect students to complete the tasks. Student behavior indicated a lack of engagement and enjoyment.

Student responses to the informal questioning are also consistent with the statistical and observational results. The students found the electronic whiteboards and gaming engaging separately as well as in conjunction with each other. Student comments reflected that the activities were fun indicating a high level of engagement. They also stated that this made them want to learn showing an increase in motivation. Comments about the aid to visual learning, supports the variety of learning abilities of students. It was responded that most students found the electronic whiteboards and gaming to help them to understand math and did so either better then or the same as other methods of instruction.

These results were consistent with the literature. This study showed that the interactive technology and gaming increased understanding in mathematics. The literature discussed that technology was shown to aid in the academic achievement of students (Mouza, 2008). In the literature students were found to be more engaged and motivated as was found in this current study. Students preformed better in aspects of assessment in the literature as they did in the exit tickets of the described research.

Additionally, interactive methods were shown to be part of the interactive whiteboard and included sound, video, animation and enrichment of text (Mechling, 2008). The results also indicated an increased level of motivation for students to learn the content. Students were engaged by the interactivity of the whiteboard and game. Students consistently referred to the visual aspects of the whiteboards and how it helped

them to look at the information from a new perspective. Technology also increased confidence and allowed students to go beyond basic tasks (Li, 2007). They could apply what they learned through the whiteboard and games to the problems they needed to complete afterwards.

One aspect that was not considered in this research was the difference between males and females in their increased understanding of math through technology. Male students seemed to respond more favorable toward the experimental method and it is possible that their understanding of math was increased more then female students. Future research could explore the how males and females respond differently to different technological learning mediums and instruction.

Another area of future research could be how students with disabilities respond to the use of the new technologies. Observations indicated that this form of differentiated instruction would benefit students with disabilities as well as students who have low math ability.

Conclusion

Research was conducted to investigate integrating math and technology. The combination of the two has been shown through the literature to enhance the educational future of children today. The integration of interactive technology through the use of

electronic whiteboards and gaming to enhance student understanding in mathematics was investigated in this current study.

High school students (N=80) reviewed content through an electronic whiteboard and gaming. It was shown that gaming through the use of electronic whiteboards increased student achievement in mathematics by ensuring a deeper understanding of the material presented. Student assessments showed a significant increase in achievement indicating a greater understanding of the content. Observations of the instructional methods as well as student comments clearly indicated that electronic whiteboards and gaming increased engagement and motivation which also aided in the deeper understanding of mathematics.

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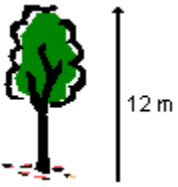

Appendix A

Sample Warm Up

Lee wants to make a model of the tallest tree in his yard for his science project. His teacher says he has to use a scale of 1 cm = 1 m. What will the height of the tree in the model be?

cm

2.
Scott is ordering wall-to-wall carpeting for a new rectangular bedroom with dimensions 12 feet × 11 feet. What is the minimum amount of carpeting that Scott should order?

square feet

3.
Jeff and Elaine went to the ASPCA to get a pet. In the dog area there were twice as many German shepherds as there were labs, but only $\frac{1}{3}$ as many German shepherds as there were retrievers. If there were 24 retrievers, how many dogs were there in all?

dogs

4.
What is the approximate circumference of a circle with radius 3?

1.
7.
0
7

3.
1
8.
8
5

2.
9.
4
2

4.
2
8.
2
7

5.
In general, the volume of a prism is the product of

1. its height and width

3. the area of the base and its height

2. its length, width, and height

4. its length and

6.
Alice and Martha are planning to follow the same directions on a trip to a campground. Alice has to leave 3 hours after Martha because of an appointment. Martha leaves at 9am and drives 40 miles per hour. Alice travels 60 miles per hour. At what time should Alice catch up to Martha?

pm

Appendix B:

Sample Exit Ticket

Mr. James just put up a new pool. It is a circular pool with a diaeter of 24 feet. If Mr. James wants to buy a solar cover to fit the top of the pool, what size cover should he buy?

1.
5
0
sq
ua
re
fe
et

3.
5
0
0
sq
ua
re
fe
et

2.
7
5
sq
ua
re
fe
et

4.
2,
0
0
0
sq
ua
re
fe
et

2.
14 plums cost $2.00. What is the cost, to the nearest cent, of 50 plums?

$

3.

A tree casts a shadow 4 ft. long while a house casts a shadow $2\frac{1}{2}$ feet long. If the house is 26 ft. high, how tall is the tree? Round to the nearest foot.

_____ ft.

4.
Mike ran a race in 5 minutes less than Steve, and Steve ran the race in 12 minutes less than Art. If Art ran the race in 35 minutes, how long did it take Mike to run the race?

_____ minutes

5.
Roy is making a pattern with tiny square tiles.

 $4\frac{1}{2}$ mm

What is the perimeter of this tile?

_____ mm

6.
Which rectangular package would require more wrapping paper to cover?

1. Package A: measures 10 in. by 6.5 in. by 12.75 in.
2. Package B: measures 9 in. by 7.25 in. by 11.5 in.