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The effect of game-based learning on middle school students' academic achievement

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The purpose of this literature review is to explore the connections of paratexts and multiple literacies in game-based learning to traditional literacies and examine the effectiveness of game-based learning on middle school students' academic performance in STEM subjects. Thirty peer-reviewed journal articles with a combination of quantitative and qualitative methods as well as literature reviews were surveyed. Research shows game-based learning is a viable instructional method that offers close connections to traditional literacies in the classroom and an opportunity for improving student academic achievement when implemented purposefully in STEM content areas. Recommendations for teachers' effective implementation and the future directions for the research are discussed.

THE EFFECT OF GAME-BASED LEARNING ON MIDDLE SCHOOL STUDENTS' ACADEMIC ACHIEVEMENT

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Abstract

The purpose of this literature review is to explore the connections of paratexts and multiple literacies in game-based learning to traditional literacies and examine the effectiveness of game-based learning on middle school students' academic performance in STEM subjects. Thirty peer-reviewed journal articles with a combination of quantitative and qualitative methods as well as literature reviews were surveyed. Research shows game-based learning is a viable instructional method that offers close connections to traditional literacies in the classroom and an opportunity for improving student academic achievement when implemented purposefully in STEM content areas. Recommendations for teachers' effective implementation and the future directions for the research are discussed.

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Introduction

Children are encouraged to learn through exploration and play during their early years of development. Opportunities to learn in this manner drastically change as children mature. Experiences that allow children to explore and play to learn will develop creative and critical thinking which is essential to their academic success (Davies et al., 2013; Holmes, Liden, & Shin, 2013; International Association for Development of the Information Society, 2012; Won & Han, 2010). As the availability of technology increases in classrooms and homes, educators have the opportunity to create unique learning experiences that build upon students' literacies developed outside of the classroom such as gaming literacies. To achieve this, educators need to analyze previous research concerning the implementation and effectiveness of game-based learning. The purpose of this literature review is to explore the use of game-based learning in middle school classrooms to determine the effect on student academic achievement.

There is a growing concern that United States' student achievement in math and science is falling behind other countries and that the United States is losing its innovative advantage to other countries (Association of American Universities, 2006; Augustine, 2006; Coble & Allen, 2005; Kuenzi, 2008; U.S. Department of Education, 2007). A report prepared for members of the United States Congress expressed concern regarding student achievement in Science, Technology, Engineering, and Math (STEM) (Kuenzi). While assessments showed improvement in areas of math and science, the majority of United States (U.S.) students were not proficient in math and science. Only one-third of U.S. students in fourth and eighth grade were proficient in math. Less than one-third of U.S. students in fourth and eighth grade were proficient in science. Etter (2011) noted

middle school is when most students begin to lose interest in math and science. This loss of interest in math and science results in fewer students taking fewer math and science classes, which ultimately reduces the number of students pursuing degrees for careers in math and science fields. The number of qualified U.S. students for STEM jobs is declining, as careers in these areas continue to increase. According to Kuenzi, while the number of students earning college degrees in STEM areas is increasing, undergraduate STEM degrees accounted for fewer than 16% of all degrees awarded (2008). "The United States has one of the lowest rates of STEM to non-STEM degree production in the world" (Kuenzi, p. 18).

Game-based learning can provide an effective way to offer engaging and motivating learning experiences that would increase student interest in STEM content areas and improve student academic performance. Research in this review will show this instructional method may provide an avenue for educators to create learning experiences that challenge and engage students (Chang, Wu, Weng, & Sung, 2012; Meluso, Zheng, Spires, & Lester, 2012), caters to students' interests and needs (Giannakos, 2013; Mayo, 2009), prepares students to problem solve and collaborate with others (Chang et al., 2012, Yang & Chang, 2013), and take responsibility of their own learning (Liu, Horton, Olmanson, & Toprac, 2011; Meluso et al., 2012). To achieve this, previous research must be analyzed for effective implementation of game-based learning to promote success for all students at the middle school level. This review will examine the relationship between gaming literacies and traditional literacies, explore the effect of game-based learning on student literacy, academic achievement in math and science, and higher order thinking, as well as consider the effect of student engagement and self-efficacy. Results from this

review will inform, support, and guide educators, administrators, and researchers regarding the effective integration of game-based learning in middle school classrooms to support student academic achievement in literacy, math, and science.

The following research questions guided this literature review:

1. What effect does the use of game-based learning have on literacy education?
2. What effect does game-based learning have on student interest in math and science?
3. What effect does game-based learning have on students' learning?

Methodology

Resources for this literature review were located using the University of Northern Iowa Rod Library's *One Search*, *EBSCOhost Professional Development Collection*, *Academic Search Elite*, *Education Resource Information Center* (ERIC), and *Google Scholar*. These search engines and databases were chosen for their ability to narrow results to peer reviewed resources. Due to the recent interest and growth of game-based learning in education, resources from educational blogs *Edutopia* and *MindShift* published within the past five years were also considered for information regarding current practice. The search terms used during research included: *game-based learning, games, video games, play, middle school, elementary, "STEM" (Science Technology Engineering Math), math, science, literacy, reading, writing, learning, self-efficacy, motivation, engagement, achievement*, and *performance*. Then various combinations of these terms were used to narrow down the pool of the articles. The snowball technique was also adopted where resources were located through the references listed in peer-reviewed articles retrieved while researching, and selected for the literature review.

The initial criteria for selecting resources during research were based on articles being peer-reviewed, publication within the last ten years, articles related to game-based learning in the classrooms at all grade levels, articles addressing math, science, reading, writing, or literacy content areas, and articles addressing student achievement in content areas. Resources were then narrowed to articles addressing grades four through eight, or middle school. Priority was given to quantitative research. However, qualitative research was considered if it matched all initial criteria and the grade level addressed in this literature review. Reliability of the resource was evaluated for inclusion in the review.

Resources were included if they were peer-reviewed articles, published in scholarly journals, by well-known authors on the topic, or experts in the field. Other factors considered were the number and currency of references included for the resource and the number of citations of the source in other articles.

Analysis and Discussion

This section begins with the analysis of peer-reviewed articles regarding the relationship between game-based learning and literacy. Then it examines the effect of game-based learning on student interest related to content, gender, and self-efficacy. It ends with a review of research exploring the impact of game-based learning on students' higher order thinking and academic achievement.

Literacy Education Connections

Game-based learning provides a connection to literacy. Playing games by themselves have their own literacy, from understanding the basic structure and rules of the game, to understanding how to play and accomplish different parts of the game. The literacy of playing a game is similar to the literacy of reading a book. The literacy of creating a game is similar to the literacy of writing. Game-based learning deals directly with analytical thinking, problems solving, and decision making, which is an integral part of traditional literacies. "What tend to go unrecognized are the existing practices students bring to school that are multimodal and highly sophisticated technologically" (Larson & Marsh, 2005, loc. 1888). "Instances of youths' out-of-school digital literacy proficiencies have impacted pedagogical practices in schools where the image is slowly replacing text and students increasingly learn curriculum content visually" (Walsh, 2010, p. 24-25).

According to Larson and Marsh "a multidisciplinary theory of literacy learning values the experiences and knowledge that children bring to the classroom. Students count." (loc. 2007). Building upon the experiences and knowledge brought into the classroom by children validates them and the worth of their background. Common themes were prevalent throughout the research where gaming literacy was directly

connected to and supported traditional literacy: the use of paratexts, multiple literacies, and their impact on student engagement.

New Literacy. Exploring paratexts provides an authentic way for teachers to connect their curriculum with digital games (Walsh, 2010). Paratexts are multimodal expository and procedural texts such as guides, tutorials, and reviews ranging from printed material to videos. These challenging expository and procedural texts provide a relevant connection to students' lives. As a result, students are willing to take the time to understand them (Apperley & Walsh, 2012).

Walsh (2010) presented two case studies that explored paratexts as an authentic way for teachers to connect their curriculum with digital games. Both studies involved Australian Year 7 students who found traditional print-based literacy instruction challenging and uninteresting. In the first case study students researched, reviewed, presented their favorite games, compared games to each other, and wrote their own opinion of the games played. In the second case study Year 7 students researched and reviewed digital games, and then designed their own digital game. Both studies reported increased student engagement and more creative, higher quality work that was closely related to the literacy curriculum. The demonstration of higher engagement and proficiency in traditional literacies was contributed to the connection digital games have to students' everyday lives. Walsh found students who struggled with traditional literacy instruction, met or exceeded the learning goals during these case studies.

In a subsequent article, Apperley and Walsh (2012) detailed the relationships between digital games literacy and literacy in the classroom and provide a heuristic for understanding gaming to inform instructional design as well as professional development.

"When children and young people read, research, and design paratexts they are engaged in relevant print-based and multimodal literacy practices, making these activities a fluid example of situated learning" (p. 117). Creating paratexts provides students the opportunity to demonstrate their understanding and analysis of the game through multiple modes of communication. Paratexts "should not be regarded as merely practical but also as imaginative and creative outputs that include writing, digital artwork, visual and audio design and new game designs" (p. 117). Digital paratexts provide a strong connection between the literacy of digital games and traditional literacy. Students' reading, writing, speaking, and listening about gameplay mirrors the forms of literacy in the classroom. When digital game paratexts are recognized as a form of expression, they will provide another opportunity for digital games in the educational environment.

Multiple literacies. In addition to supporting traditional literacy, the research evidence showed game-based learning also supports several other aspects of literacy: Bernstein's Invisible Pedagogy, new literacy, critical literacy, techno-literacy, and socio-historical literacy as introduced by Larson and Marsh (2005). Not only does gaming blur the lines between content areas as described in Bernstein's Invisible Pedagogy, learning becomes student centered through self-pacing, just in time instruction, immediate feedback and recognition. Gaming in the classroom supports new literacy through the use of formal and informal multimodal texts. Critical literacy is developed through interaction, decoding, and analysis of the game during gameplay. Game-based learning supports techno-literacy through students' ability to make meaning through the interaction with text, images, sounds, and movement, then reacting according to the response desired. Sociocultural-historical literacy is promoted through social interaction

during gaming that constructs new knowledge based on the game and interaction with peers. "Digital games and school-based literacy practices have much more in common than is reported in the research literature" (Apperley & Walsh, 2012, p. 115).

The previous studies regarding literacy and paratexts also addressed aspects of gaming literacy that support traditional and new literacies. Apperley and Walsh (2012) discussed the relationship between gaming literacy and traditional literacy through paratexts, stating they not only provide a link to traditional literacies, but also a path to new literacies and provide a low risk entry of game-based learning into the classroom. Games and their paratexts provide opportunities to emphasize system and critical thinking. Students engage in multimodal literacy through text, images, audio, and video in games and paratexts that require students to analyze and evaluate the information based on the source, their knowledge of the game system, and the impact their actions or inactions have in the outcome of the game. They concluded game-based learning could be an effective method of instruction for multiple literacies in the classroom. The case studies (Walsh, 2010) of two middle school English classrooms in Australia investigated the impact of writing game reviews and analyzing and creating gaming paratexts, gaming support texts such as FAQs and guides, on students' traditional literacies. Researchers found through consumption and creation of paratexts students use multiple literacies to understand and participate in the game culture. Students also develop system-based thinking and multimodal literacy when interacting with paratexts and creating them. Researchers concluded students' interaction with playing, designing, and consumption of digital games and paratexts showed increased engagement and higher performance.

Gee (2007) discussed three areas of current research: situated cognition, new literacy studies, and connectionism. Thirty-six learning principles of gaming were presented and how they support multiple literacies. In his book, he states these learning principles are embedded within the game and should be applied to instruction with or without the use of games. Games support new literacies by requiring players to learn and think in new ways, presenting difficult challenges, and providing feedback and scaffolds in order for players to learn how to play, which develops problem-solving skills and promotes collaboration. Gee also presents the value of gaming as it promotes the literacy of problem solving and reduces the risks of failure. "Players are encouraged to take risks, explore, and try new things" (Gee, p. 216). Games provide challenges that are solved through trial and error, therefore students learn through making mistakes and correcting them.

Interest and Attitudes Toward Math and Science

Besides supporting traditional literacy and new literacies presented above, game-based learning can allow middle school students to develop positive attitudes toward math and science while increasing engagement. Meluso, Zheng, Spires, & Lester, (2012) stated, "well-designed educational games have the potential to transform STEM teaching and learning because they can simulate real-world complexity and make learning more connected to students' personal lives outside of the school context" (p. 1). The research evidence shows that the use of game-based learning in education with an increasing focus in areas related to STEM subjects and characteristics can support student achievement.

In a mixed method study, Ke (2008) applied qualitative and quantitative methods to evaluate the effect of the educational use of video games in a summer school math

class on student achievement and attitudes toward math. Fifteen fourth and fifth grade students participated in the study over a five-week period, meeting two times each week for a two-hour period of time. Quantitative data was collected through a math attitude inventory and a math test given before and after the study. Qualitative data was collected through observations, student think-alouds, and document analysis of student time on task. Quantitative results from this study showed the use of gaming increased positive attitudes toward math, however it showed no correlation to improved student achievement. Qualitative results from this study showed student engagement was diminished when the game was too difficult, too easy, or required the students to leave the game play for the math content of the game. When math learning was embedded in game play, researchers noted increased student effort and engagement. Even though there were several limitations to this study: small sampling, short period of time, conducted during summer school, and students from one school; it is important to note the increase in positive attitudes toward math. Researchers did note positive attitude played a factor in game performance and content achievement, even when they were simplistic math drill games. Caution was advised that not all math games would engage all students.

Conversely Giannakos' (2013) two-part study of 13 year-old students took place over a four-week period. The first part of the study examined 41 students' performance in traditional learning compared to game-based learning. The second part of the study examined how 46 students' attitudes impact performance. In each study students were assigned to groups based on a pre-test to form similar achieving groups. Groups were assigned to the experimental group using game-based instruction or control group using traditional instruction. Quantitative data was collected through surveys completed by

students and qualitative data was collected through researcher observations to determine the effect of game-based learning on student enjoyment and achievement. Researchers found a strong correlation between student attitudes, enjoyment, and game-based instruction. Game-based learning can also enhance math and science instruction in multiple modes to meet the needs of varying abilities and learning styles of middle school students. This finding is confirmed by a literature review regarding the use of video games in science, technology, engineering, and math (STEM) content areas (Mayo, 2009). Mayo noted, "games are a highly interactive medium with many key attributes shared with sophisticated pedagogical approaches" (p. 82). She concluded that gaming principles of self-pacing, scaffolding learning, reinforcement, immediate feedback, and reward elements encourage student engagement, increase positive attitudes, contribute to higher levels of achievement, and mirror best practice in instructional design.

Beyond a regular classroom, game-based learning can increase engagement and positive attitudes of middle school students (Schaaf, 2012). This experimental design study included 280 students from grades three through five in 12 homerooms of an intermediate school in Maryland. The study examined the effects of game-based learning on enjoyment and engagement compared to traditional methods. Homerooms were randomly assigned to the experimental or control group for a duration of eight lessons. Each of the classes used the same objectives and assessments. Research data included surveys and observations. All students in both groups completed an attitudinal survey at the end of each lesson to measure students' perception of their own enjoyment and engagement during the lesson. The results from this survey showed that students who were involved in game-based learning had a higher level of enjoyment in six out of eight

trials. Observations by researchers documented time-on-task behavior to measure engagement. Student groups from both the experimental group and control group were randomly selected for observation. Each student in the group was observed for 120 seconds to determine each individual's time-on-task. Time-on-task times recorded for each student were averaged to result in one score for each of the groups to allow for comparison between game-based learning and the control group. Higher time-on-task behavior was reported for the game-based learning group compared to the control group. "The data from the study suggests Digital Game-Based Learning is a sound instructional strategy that promotes students engagement" (Schaaf, p. 61). "However, several trials did demonstrate that the alternative strategies produced more lesson engagement and a higher time-on-task group average than DGBL" (Schaaf, p. 61). Schaaf emphasized that game-based learning is not always the best instructional solution and should only be utilized when it meets the instructional needs of the content and the students.

Gee (2007) also presented the value of gaming as it promotes the literacy of problem solving and reduces the risks of failure. "Players are encouraged to take risks, explore, and try new things" (Gee, p.216). Students learn through play and exploration with a reduced negative impact of risk taking and failure. Students are trained to seek the correct answer and as a result become afraid of making errors and answering incorrectly. Games provide the opportunity to openly explore and learn through trial and error, without the fear of being wrong. Games provide challenges that are solved through trial and error, therefore students learn through making mistakes and correcting them. Engagement and motivation are increased through setting and attaining achievable

challenges and goals. Game-based learning provides these challenges along with immediate feedback and rewards to guide students' progress.

Games and gender. Researchers also investigate the effect of game-based learning in regards to gender. A survey of 42 middle school students, grade six through eight, was conducted to determine video game preferences based on gender (Kinzie & Joseph, 2008). Data was collected from students through a survey developed by the researchers based on game activity modes. The survey was tested and revised with 17 students during a former study completed by Joseph and Kinzie in 2005 (Joseph & Kinzie, 2005, as cited by Kinzie & Joseph, 2008). The survey collected data in four areas: video game experience and demographics; preferences for character, setting, and help; activity mode preference; and attitudes toward activity mode. The survey identified six different activity modes: active, explorative, problem solving, strategic, social, and creative. Data from the survey showed explorative games as the preferred activity mode, with strategic games and social games being the least preferred. When results were analyzed based on gender, the results showed boys preferred active game mode followed by strategic game mode. Results showed girls preferred creative game mode followed by explorative game mode. Problem-solving and social game modes showed no preference differences between genders. Considerable differences were found between genders regarding their attitude toward game modes. Attitudes of boys were significantly more positive toward active and strategic mode games. Attitudes of girls were significantly more positive toward creative mode games. In order to appeal to all students regardless of gender, Kinzie and Joseph (2008) encourage the use of explorative and problem-solving games. The survey showed these activity modes appealed to both genders equally.

Furthering the investigation of the effect of game-based learning in regards to gender is a study by Kim and Chang (2010). Researchers collected data regarding fourth grade math achievement through the National Assessment of Educational Progress. Due to the sizeable and diverse pool of participants, along with the analysis of subgroups, this research may offer insight to the general population as well as the diverse learners of fourth grade students regarding game-based learning. Surveys completed by teachers collected information regarding instructional practices in the classroom, learning environment, and student behavior. The relationship between student math achievement data and the teacher reported frequency of computer game use was examined. Data gathered were analyzed using the following variables: social economic status, English language learners, gender, and interaction. Of noted importance, the data suggests significant relationships with all variables regarding game-based learning. However, only the variable of gender will be presented for the purpose of this review. A significant difference was noted based on gender. Increased computer game use in the math classroom had a direct correlation with increased math achievement for boys, however, not with girls.

Furthering this research, an Australian study (Lowrie & Jorgensen, 2010) surveyed 426 fifth and sixth grade students to determine differences between boys and girls in the amount of time spent playing video games each week and their preferences of game play. Researchers purposefully selected two locations to administer the surveys to better represent the student population. Surveys were administered in two different states, with one location from a rural inland city and the other location from urban coastal city. One school was in the catholic education system and the second school was in the state

school system. Surveys were given to all fifth and sixth grade students from these schools that received parental consent. The results showed a relationship between gender and the amount of time playing video games, with 49% of boys playing video games more than three times in a week compared to 32% of girls. The data showed the most significant differences of game play was reported on non-school days, with 34% of boys playing video games more than three hours and 16% of girls playing more than three hours. A connection was also established with gender and genre preference for video games. Boys and girls both preferred simulation games above all other game genres. Beyond those results, boys preferred action games followed by adventure games and girls preferred other categories followed by adventure games. These results confirm and provide additional insight to the study by Kinzie and Joseph (2008) regarding boys and girls game mode preferences.

Expanding the research on the effect of game-based learning and gender, Robertson (2012) completed a field study regarding the creation of games in Scotland. There were 25 participants in the study, ages 11 and 12. The field study took place over a period of six weeks. Robertson explored the game creation skills of students in regards to game design and storytelling to determine if there would be differences between techniques boys and girls used to create their game. Researchers hypothesized girls would be at an advantage when creating a game story line due to their literacy skills and strength in developing characters, story lines, and narrative writing. They also expressed concern that girls would be at a disadvantage in creating a game due to the lack of experience with video games compared to boys. The study collected quantitative and qualitative data through the assessment of the final game created and teacher observations

while students were creating their games. Student-created games were assessed on a scale from zero to ten in the following areas: storyline, visual appearance, player guides, purpose of the game, game player choices, characters, dialogue, imagination, and challenge. The game was assessed by first inspecting the different game elements, and then playing the game. Each game was assessed by two researchers who were experts regarding game creation. Overall, the quantitative data showed girls performed better in creating their video games. Qualitative data attributed this performance to the girls' improving their games based on feedback from peers and their experience with fictional texts and writing. This study confirms previous studies regarding the different preferences towards video games and also cautions that games in the classroom should not reinforce existing gender-based labels or stereotypes in regards to content and achievement. "Girls may be encouraged to engage with technology as a result of their enjoyment of storytelling while boys may be motivated to develop their storytelling skills through their interest in gaming technology" (Robertson, 2012, p. 397).

Self-efficacy. When students are motivated to learn by playing games, they become more confident in their beliefs in their ability to complete tasks. Bandura (1994) states, "the most effective way of creating a strong sense of efficacy is through mastery experiences" (p. 2). Game-based learning can provide an avenue for these experiences in the classroom. Research shows a strong correlation between self-efficacy and science achievement (Britner & Pajares, 2006). According to Meluso, Zheng, Spires, and Lester (2012), "another fruitful area for game-based learning research is increasing students' self-esteem as learners in the classroom, specifically in the area of science self-efficacy" (p. 497). They conducted a quantitative study of fifth graders in southeastern United

States to examine the effect of single-player and collaborative playing condition on the participants' self-efficacy toward science. This study took place in a public magnet school with a diverse ethnic and socioeconomic population over a period of four days. Students in six different fifth grade classrooms were randomly assigned to either the single-player or collaborative playing condition. Data was collected through pre- and post-assessments regarding their self-efficacy and science knowledge. Data for this study was only analyzed for students who completed both the pre- and post-test and participated in all four sessions, reducing the number of participants from 100 to 66. Results showed all participants significantly increased their scores from pre- to post-test on self-efficacy regardless of the playing condition. Both playing conditions also showed significant increases of science content knowledge from pre- to post-test (Meluso, et al.).

A similar study was conducted by Liu, Horton, Olmanson, & Toprac, (2011), who collected quantitative and qualitative data from sixth grade students in southwestern United States to examine the relationship between motivation and science learning through game-based learning. Over three weeks during their science class, 220 students played *Alien Rescue* as a self-paced unit. Each student worked in small groups and had their own computer. The two teachers who taught science classes had used the program previously, and received training to implement this type of instructional environment. Participants completed pre- and post-tests reflecting the science content, factual and application, to be learned during game play. Students also completed a motivation questionnaire and answered six open-ended questions about their experience playing *Alien Rescue* upon completing the unit. Results showed increased science scores from pre- to post-test were linked to the participants' self-efficacy, "perceived competence."

The students' "perceived competence" was the best predictor of achievement on the post-test. The higher the "perceived competence," the higher the post-test score (Liu et al., 2011).

Confirming this is a literature review (Mayo, 2009) regarding game-based learning and STEM education. Mayo states game-based learning offers immediate feedback and rewards which leads to increased self-efficacy and increased achievement. In the review, the author reports learning outcomes from various studies covering multiple content areas and grade levels (middle school, high school, and college) with an increase of 7 to 40% when using game-based instructional methods compared to traditional lecture methods. The author attributes this to the ability of games to provide differentiation, self-pacing, multimodal representation of information, feedback, and rewards. Mayo believes that games are about the most interactive types of content existing today with many key attributes shared with sophisticated pedagogical approaches. He suggests developing high quality academic games to reach game-based learning potential to deliver science and math education to millions of users simultaneously. His review draws a good connection between playing games and academic learning.

Learning

Game-based learning provides an additional instructional method for educators to consider in the classroom when designing learning experiences to promote student learning. "The learning principles that good games incorporate are all strongly supported by contemporary research in cognitive science" (Gee, 2003, p. 1). These learning principles support student learning with or without the use of games in the classroom.

Research presented in this section of the review presents connections between game-based learning, higher-order thinking, and achievement.

Higher-order thinking. Game-based learning engages students' higher-order thinking skills through opportunities to problem solve, evaluate, analyze, and create which are embedded within the game. Chang, Wu, Weng, & Sung (2012) conducted a study of fifth grade students in Taipei over a two-week period that compared the effects of game-based learning and traditional paper-based instruction on students' problem-solving abilities. The quasi-experimental study assigned students to the experiment group that used the game-based problem posing system or to the control group based on their classroom assignment. Two classes were assigned to the experimental group and two classes were assigned to the control group, with the same teacher for both groups. The study was conducted in two sessions of eighty minutes in a span of two weeks. Each group participated in pre- and post-tests to measure students' problem solving proficiency. For the pre- and post-tests students created ten problem-posing questions that were rated based on four criteria: accuracy, flexibility, elaboration, and originality. Results showed significantly higher post-test scores of participants in the game-based learning group compared to the traditional paper-based instruction. Results also showed game-based learning promoted increased learning for students with lower scores on the pre-test. Researchers concluded, "problem-posing activities enhanced by technological tools can be beneficial to the learning process" (Chang, et al., 2012, p. 784).

Yang and Chang (2013) found similar results in a quasi-experimental study of seventh grade students over a nineteen-week period comparing the use of Digital Game Authorship (DGA) and Flash Design as instructional methods for biology. Students were

randomly assigned to the experimental or comparison group. Both experimental and comparison groups were taught by the same teacher. Pre-tests, post-tests, and delayed post-tests were administered to all participants to measure concentration, critical thinking, and achievement. Comparison of pre-test and post-test scores from both groups showed no significant improvement in concentration for the experimental group or control group. In contrast, "DGA participants had significantly greater improvements in critical thinking than comparison group participants, as well as significantly better retention when tested a month later" (Yang & Chang, p. 341). Results regarding academic achievement showed improved academic scores for DGA participants on the post-test and delayed post-test. These studies both indicate a positive correlation between game-based learning and improving students' higher-order thinking.

Academic Achievement. Higher-order thinking, self-efficacy, engagement, and attitudes all play a role in supporting student academic achievement. Game-based learning provides a viable instructional method to develop these characteristics in order to advance the achievement of all students. As mentioned earlier, in his review about research evidence of video games for STEM disciplines in the USA, Mayo (2009) notes that game-based learning can produce a significant increase in learning over traditional lecture for its ability to meet individual needs, pace learning individually, provide immediate and constructive feedback, and present learning in multiple modes of communication. Chang et al.'s study (2012) in Taipei also demonstrated significant increases of achievement with the use of game-based learning for all students, including low performers on the pre-test. It was concluded that "...problem-posing activities enhanced by technological tools can be beneficial to the learning process" (p. 784).

In a recent study investigating problem solving and perceived learning over a five-month period, Barzilai and Blau (2014) studied the effect of a web-based math game beyond the classroom. When potential participants accessed the website they were given the option to volunteer for the study. The website was accessed 5,687 times during the five month period. Among 644 participants that responded to the survey, 182 participants aged six through 14 completed the survey and post-game assessment. Participants were randomly assigned to one of three game play conditions: "play only," "play and study," and "study and play." The problem-solving assessment was administered prior to game play and at the conclusion of game play as a similar problem with different numbers to measure the effect of game play on problem-solving achievement. After completing the game, participants completed a survey consisting of four questions on a six-point scale and one open ended question about their perception of learning. Overall, participants showed no significant gains from gameplay. However, when broken down by group, the results indicated the "study and play" group had significantly increased learning achievements when compared to the learning achievements of the "play only" and "play and study" groups. In regards to perceived learning, the "play only" group reported significantly higher than the "play and study" and "study and play" groups. The differences reported between the "play and study" and "study and play" groups regarding perceived learning were insignificant. Limitations of this study include the short duration of a single session and the volunteers may not represent the generalized student population where they are in a non-voluntary learning setting. Researchers concluded the scaffolding provided prior to play increased the achievement. They recommend, "the

scaffolds be designed for learning and enjoyment" while incorporating game visuals and interactive elements "to make them visually related to the game world" (p. 77).

Spires, Rowe, Mott, & Lester, (2011) examined the relationship of game-based learning and problem solving to science achievement in the classroom. This study was completed prior to the introduction of the standard microbiology curriculum. Participants consisted of 137 eighth grade students with diverse ethnic backgrounds attending a public magnet school in the southeastern United States. Researchers asked participants to take pre-tests and post-test of eight factual questions and eight application questions to measure content acquisition and the ability to apply it beyond the classroom. Data was also collected on students' problem-solving performance during game play through the completion of goals within the game. Scaffolding was provided during game play to support students' needs to meet the goals. Data was also collected on student use of supports within the game. Results showed students who interacted with the game supports and scaffolding provided within the game, completed more goals within the game and performed better on the posttest. One limitation of the study was the use of multiple-choice questions to gather information on problem-solving abilities. Another limitation was the game environment did not mirror the multimodal engagement of commercial games. While the results demonstrated the potential of game-based learning, researchers cautioned there is not an education approach that will effectively meet the needs of all students and all subjects. They concluded that game-based learning can transform instruction and learning in the classroom.

However, in the mixed-method, five-week study, presented in a previous section, Ke (2008) found no significant increase in achievement with implementation of game-

based learning for the fourth and fifth grade students. This confirms results of previous studies (Dempsy et al., 1994; Dempsey, Rasmussen, and Lucassen, 1996, as cited by Ke). The study however, did show an increase in positive attitudes toward math. Recommendations in this study advised designing game-based learning where the game and learning goal are closely related, clearly communicated to the learners, and concealed in the game.

Giannakos (2013) advanced the research findings when investigating the factors affecting learning performance in game-based learning for math ability over a four-week period. The experimental group engaged in game-based learning while the control group engaged in traditional instruction methods. Both groups were located at the same school in Greece and based instruction around the same objectives and content. At the beginning of the study all participants completed a performance pretest. At the conclusion of the study all participants completed a performance test. Results from this performance test found no significant difference between traditional instructional methods and game-based learning, demonstrating gaming as a viable instructional method. In the second portion of the study, participants completed a survey regarding the enjoyment of game-based learning, willingness to participate in game-based learning, happiness regarding the game, and performance in the game. A positive correlation was found between enjoyment and performance in the game. Qualitative data was also collected from teachers during the intervention. Teachers noted student reaction and enthusiasm toward game play was overall positive. During gameplay students played the games quietly with intermittent outbursts as students progressed through levels. Also of interest were the observations of students assisting each other as they progressed through the game. "The research findings

revealed that learners reflecting high enjoyment are more likely to acquire knowledge through the game" (Giannakos, 2013, p. 438).

In summary, research evidence shows connections between game-based learning, higher-order thinking, and academic achievement. However, due to limitations of the studies regarding participants, duration, and diversity, caution must be used in applying these results to the general student population.

Conclusions and Recommendations

The research evidence demonstrates connections between gaming and literacy. Game-based learning has positive effects on traditional and new literacies by advancing traditional and new literacies, reinforcing and extending traditional and multiple literacies, and blurring the lines between content areas (Apperley & Walsh, 2012; Gee, 2007; Walsh, 2010). The integration of gaming into literacy instruction builds upon the experience and knowledge children bring from outside the classroom and is comparable to classroom literacies. Game-based learning provides a framework teachers can build upon and connect to literacy curriculum, develops students' systems thinking approach, increases student engagement, improves performance of struggling students, supports multimodal communication, and facilitates self-directed learning through exploration and play (Apperley & Walsh, 2012; Gee, 2007; Walsh, 2010).

Additionally, game-based learning can impact student interest, attitudes, and self-efficacy regarding content area learning. Game-based learning improves students' attitudes and engagement in math and science content areas. (Giannakkos, 2013; Ke, 2008; Mayo, 2009; Schaaf, 2012). Research showed boys' and girls' preferences toward the type of game play implemented in the classroom were significantly different and directly impacted achievement and attitudes toward learning. Boys preferred action and adventure games, while girls preferred creative and explorative games. Simulation and problem-solving games appealed to both genders. (Kim & Chang, 2010; Kinzie & Joseph, 2008; Lowrie & Jorgensen, 2010; Robertson, 2012). These genre preferences should be taken into consideration and inform instructional decisions for game-based learning. Several studies (Britner & Pajares, 2006; Liu et al., 2011; Mayo, 2009; Meluso

et al., 2012) indicated a strong correlation between game-based learning and improved self-efficacy, which directly impacts their achievement and attitudes toward math and science.

Furthermore, there are strong connections between game-based learning, higher-order thinking, and academic achievement. Game-based learning provides opportunities to engage and develop students' higher-order thinking skills through game elements to problem solve, evaluate, analyze, and create within the game (Yang & Chang, 2013; Chang et al., 2012) Results also show significant increases in academic achievement with the use of game-based learning, including lower performing students (Barzilai & Blau, 2014; Chang et al., 2012; Giannakos, 2013; Ke, 2008; Mayo, 2009; Spires et al., 2011). Game-based learning has the ability to transform learning in the classroom. However, researchers (Spires et al., 2011) cautioned one instructional approach can not meet the needs of all students.

Research in this review suggests that game-based learning is a compelling and viable instructional practice to reinforce and extend traditional and multiple literacies, (Apperley & Walsh, 2012; Gee, 2007; Walsh, 2010), encourage students' interest in math and science (Giannakos, 2013; Ke, 2008; Mayo, 2009; Schaaf, 2012), improve students' attitudes (Giannakos, 2013), increase students' engagement (Chang et al., 2012; Meluso et al., 2012), promote students' self-efficacy (Britner & Pajares, 2006; Meluso et al., 2012), develop students' higher-order thinking (Yang, & Chang, 2013; Chang et al., 2012), and support students' academic achievement (Yang et al., 2013; Chang et al., 2012; Meluso et al., 2012; Giannakos, 2013). As an instructional strategy, game-based learning proved to be as effective as traditional methods (Giannakos, 2013). Other studies

found game-based learning had the potential to increase student achievement in math and science content areas (Chang et al., 2012; Barzilai & Blau, 2014; Meluso et al., 2012; Yang & Chang, 2013; Mayo, 2009). When implemented thoughtfully into classroom instruction with strong ties to content, game-based learning provides an engaging instructional strategy that matches the needs of the learner, provides immediate and continual rewards and feedback, while increasing student interest and self-efficacy toward science and math (Mayo, 2009).

Instructional design should be based on sound pedagogical decisions to meet students' needs. Game-based learning is not a blanket method that will fit all students or all content areas. Caution should be used when implementing game-based learning to ensure it is the best instructional practice for the students and content. Game-based learning could be the intervention needed to turn around low proficiency scores in math and science, and prepare students to enter STEM fields at the secondary level and as a career.

Further research regarding game-based learning in relation to literacy needs to be completed at varied levels with diverse subgroups looking at student engagement and student achievement over longer periods of time. While connections of game-based literacy and classroom literacy were addressed, achievement and long-term impact were not addressed. Further longitudinal studies about game-based learning needs to be conducted at the middle school level and in the STEM content areas. A research gap exists in relation to technology and engineering at the middle school level. Research needs to be completed regarding game-based learning in middle school and their effects on participation in technology and engineering participation and achievement at the high

school and secondary level as well as the influence of secondary degree choice and career path in technology and engineering. New studies need to be completed or present studies need to be replicated with larger samplings, more varied and diverse subgroups, and conducted over longer periods of time. Effects of consistent and on-going implementation of game-based learning in middle school classrooms should also be investigated in regards to engagement and achievement. Longitudinal studies regarding the consistent use of game-based learning throughout students' educational career should be conducted to determine the impact on college and career choice. Research regarding educators' and administrators' attitudes toward the use of game-based learning in the classroom needs to be completed to determine how their attitudes impact implementation of game-based learning. Research should also be conducted regarding the attitudes of students' parents regarding the use of game-based learning in the classroom.

The research and articles in this review demonstrate the connection between gaming and traditional literacy, as well as the ability to advance traditional and new literacies, suggesting that game-based learning is a viable instruction method for literacy classrooms. The research and articles in this review also demonstrate the connection between gaming and instructional practices that promote student achievement in math and science. Game-based learning provides teachers a unique opportunity to engage students in an interactive learning environment employing media students enjoy. Educators must begin to consider game-based learning as an alternative and viable instructional method for literacy, math, and science classrooms. Educators need to acknowledge, embrace, and take advantage of the opportunities game-based learning provides to engage and challenge our students. When implemented with focused intent

and purposefully integrated into the curriculum, game-based learning has the opportunity to open doors for authentic learning through exploration and play. With the advances and availability of technology and increasing interest in game-based learning, continued research evidence will help educators create unique game-based learning experiences that build upon the sound pedagogical decisions to promote academic achievement for all middle school students.

References

Apperley, T., & Walsh, C. (2012). What digital games and literacy have in common: a heuristic for understanding pupils' gaming literacy. *Literacy, 46*(3), 115-122.

Association of American Universities. (2006). *National Defense Education and Innovation Initiative: Meeting America's Economic and Security Challenges in the 21st Century*. Ipswich: Association of American Universities.

Augustine, N. (2006). Rising above the gathering storm: Energizing and employing America for a brighter economic future. *Research Technology Management, 49*(2), 61-62.

Bandura, A. (1994). Self-efficacy. In V. S. Ramachaudran (Ed.). *Encyclopedia of human behavior. 4*, 71-81. New York: Academic Press. (Reprinted in H. Friedman [Ed.]. *Encyclopedia of mental health*. San Diego: Academic Press, 1998).

Barzilai, S., & Blau, I. (2014). Scaffolding game-based learning: Impact on learning achievements, perceived learning, and game experiences. *Computers & Education, 70*, 65-79.

Britner, S. L., & Pajares, F. (2006). Sources of science self-efficacy beliefs of middle school students. *Journal of Research in Science Teaching, 43*(5), 485-499.

Chang, K. E., Wu, L. J., Weng, S. E., & Sung, Y. T. (2012). Embedding game-based problem-solving phase into problem-posing system for mathematics learning. *Computers & Education, 58*(2), 775-786.

Coble, C., & Allen, M., (2005). Keeping America competitive: Five strategies to improve mathematics and science education. *Education Commission of the States*.

Davies, D., Jindal-Snape, D., Collier, C., Digby, R., Hay, P., & Howe, A. (2013). Creative learning environments in education--A systematic literature review. *Thinking Skills And Creativity*, *8*, 80-91.

Etter, D. M. (2011). Has the US lost its technical edge?. *Mechanical engineering*, *133*(5), 36-37.

Gee, J. P. (2003). What video games have to teach us about learning and literacy. *Computers in Entertainment (CIE)*, *1*(1), 20-20.

Gee, J. P., (2007). *What video games have to teach us about learning and literacy.* New York, NY: Palgrave Macmillan.

Giannakos, M. N. (2013). Enjoy and learn with educational games: Examining factors affecting learning performance. *Computers & Education. 68*, 429-439.

Holmes, R. M., Liden, S., & Shin, L. (2013). Children's thinking styles, play, and academic performance. *American Journal Of Play*, *5*(2), 219-238.

International Association for Development of the Information Society, (IADIS). (2012). *Proceedings of the International Association for Development of the Information Society (IADIS) International Conference on Cognition and Exploratory Learning in Digital Age (CELDA) (Madrid, Spain, October 19-21, 2012).* International Association for Development of the Information Society.

Ke, F. (2008). A case study of computer gaming for math: Engaged learning from gameplay?. *Computers & Education*, *51*(4), 1609-1620.

Kim, S., & Chang, M., (2010). Computer games for the math achievement of diverse students. *Journal Of Educational Technology & Society*, *13*(3), 224-232.

Kinzie, M., & Joseph, D. (2008). Gender differences in game activity preferences of middle school children: implications for educational game design. *Educational Technology Research & Development*, *56*(5/6), 643-663.

Kuenzi, J. J. (2008). Science, technology, engineering, and mathematics (stem) education: Background, federal policy, and legislative action.

Larson, J., & Marsh, J., (2005). *Making literacy real: Theories and practices for learning and teaching.* [Kindle iPad version]. Retrieved from Amazon.com. London, England: Sage Publications.

Liu, M., Horton, L., Olmanson, J., & Toprac, P. (2011). A study of learning and motivation in a new media enriched environment for middle school science. *Educational Technology Research and Development*, *59*(2), 249-265.

Lowrie, T., & Jorgensen, R. (2011). Gender Differences in Students' Mathematics Game Playing. *Computers & Education*, *57*(4), 2244-2248.

Mayo, M. J. (2009). Video games: A route to large-scale STEM education?. *Science*, *323*(5910), 79-82.

Meluso, A., Zheng, M., Spires, H. A., & Lester, J. (2012). Enhancing 5th graders' science content knowledge and self-efficacy through game-based learning. *Computers & Education*, *59*(2), 497-504.

Robertson, J. (2012). Making games in the classroom: Benefits and gender concerns. *Computers & Education*, *59*(2), 385-398.

Schaaf, R. (2012). Does digital game-based learning improve student time-on-task behavior and engagement in comparison to alternative instructional strategies?. *The Canadian Journal of Action Research*, *13*(1), 50-64.

Spires, H. A., Rowe, J. P., Mott, B. W., & Lester, J. C. (2011). Problem solving and game-based learning: Effects of middle grade students' hypothesis testing strategies on learning outcomes. *Journal of Educational Computing Research, 44*(4), 453-472.

U.S. Department of Education. (2007). *Report of the Academic Competiveness Council.* Washington, D.C.: Department of Education.

Walsh, C. (2010). Systems-based literacy practices: Digital games research, gameplay and design. *Australian Journal Of Language & Literacy*, *33*(1), 24-40.

Won, S., & Han, S. (2010). Out-of-school activities and achievement among middle school students in the U.S. and South Korea. *Journal of Advanced Academics*, *21*(4), 628-661.

Yang, Y. T. C., & Chang, C. H. (2013). Empowering students through digital game authorship: Enhancing concentration, critical thinking, and academic achievement. *Computers & Education. 68*, 334-344.