Gaming Research for Technology Education

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Abstract

This study assesses the use of gaming to teach Science, Technology, Engineering, and Mathematics (STEM) in public education. The intent of the investigation was to identify attitudes about gaming, its use in education, and the need to utilize gaming as an integrator of STEM subject matter into the classroom. Participants included students, teachers, administrators, and parents from around the world. The evaluative instrument was launched from a website created to provide students and teachers with necessary resources for integrating gaming into the technology education classroom (Clark, 2007). Additionally, the site hosted resources and information for a new competitive event in game art and design designated for a middle and high school student association. Findings from the study indicate that professionals and students from a variety of educational backgrounds view gaming as a valuable tool for instruction; over 90 percent of the 258 participants express their support for the use of computer/video game development in education.

Introduction

Gaming is a major area of research in a variety of disciplines in education. Chief among this investigation is the use of gaming as a learning tool that attracts and motivates students at all levels of education (Rosas et al., 2003). Although the trend of the use of gaming as a learning tool has just begun, a substantial amount of research has already been conducted on the use and effects of gaming in the classroom. Considering the future growth of gaming in education, the authors identified a need to investigate the attitudes of professionals and students from a variety of disciplines pertaining to the use of gaming as a way to teach or reinforce content related to science, technology, engineering, and mathematics (STEM).

Gaming is now a nine billion dollar a year industry, with over 65 percent of all American households playing both video and computer games on a regular basis. With 94 percent of all computer games being played by people under the age of 18 (40 percent women), games were identified by the authors as a valuable tool for encouraging student learning. Considering that over 63 percent of parents believe gaming has a positive educational effect on their children, perhaps gaming can be used to enhance topics in STEM related disciplines (ESA, 2008). Gaming possesses the potential to redefine and reshape educational instructional practice. The Federation of American Scientists believes that gaming is redefining education, and by increasing students' analytical thinking, team building, multitasking, and problem-solving skills, it has the potential to develop the skill set that prospective employers want (Ben Feller, Associated Press on Gaming, 2006).

Based on the current popularity of gaming, it is the authors' belief that gaming possesses qualities that can be used to motivate struggling students in danger of dropping out of school. Knowing that students must successfully complete both mathematics and science courses to graduate from high school, the authors feel that enhancing the study of gaming through the use of game technology may be an avenue to work with students categorized as "at-risk." Therefore, this study was developed to evaluate the effects of gaming on the classroom and the attitudes that students, teachers, parents, and administrators have about the use of this technology as a pedagogical tool (Jenkins, Klopfer, Squire, and Tan, 2003).

Research in Educational Gaming

Research on electronic games has been conducted since the early 1970's. However, investigation on the psychological effects, motivational effects, and core educational potential of games was not approached until the 1980's. Since that time, major lines of research in education have been identified and pursued. Much research has been conducted on skill acquisition and the enhancement of abilities in spatial perception, visual discernment, inductive logic, and cognitive development in the science/technical aspects (Aguilera & Mendiz, 2003). Cognitive skill development through the use of electronic media, specifically gaming technologies, has been clearly identified as an area of research. A study conducted by University of Central Florida researchers identified an increase in mathematics achievement when using computer-assisted instruction. The findings from the study have assisted in formulating a design for future learning games, suggesting the integration of a simulation-based approach in gaming technology (Vogel, Greenwood-Ericksen, Cannon-Bowers, & Bowers, 2006). The implementation of gaming technologies into educational settings has provided evidence of visual-spatial skill enhancement (e.g. visual tracking, mental rotation, and target localization) as well as improvement in problem-solving skills (Schmidt & Vandewater, 2008).

Hitchcock concluded, in a study conducted in 2000, that computer-based simulation/gaming instruction increased motivation, attention, and retention of learning. Reports of heightened school achievement and increases in cognitive abilities of students through the implementation of gaming heavily stem from enhanced motivation toward learning (Rosas et al., 2003). Additionally, Rosas et al. report that students find environments that use gaming

technologies as learning mechanisms to be highly motivational. Barab, Thomas, Dodge, Carteaux, & Tuzun (2005) determined that motivation established through gaming creates an engaged classroom culture. Many times educational games attempt to portray relevant aspects of student life to inspire participation.

The future of research in gaming areas such as simulations, 3D animation, computer graphics, and even artificial intelligence, possesses potential for expanded study and application in education (Jayakanthan, 2002). Digital simulations allow new perspectives of systems, allowing users to experience varied vantage points, otherwise impossible to achieve. The current and future generations of games include powerful simulations of real-world systems that provide flexibility in decision making (Jenkins, Klopfer, Squire, and Tan, 2003). These advances in technology open areas of research on the technical aspects, as well as the educational implementation of gaming into areas that have yet to be pursued.

Scientists consider the use of gaming in education as a way to captivate student interest and motivate them to practice self-learning outside of the classroom. Also, the Federation of American Scientists, which typically weighs in on matters of nuclear weaponry and government secrecy, recently declared that video games possess qualities that can redefine education. The theory behind this is that the study of gaming can teach students the 21st century life skills that employers seek; these include analytical thinking, team building, multitasking, and problem solving under duress (Ben Feller, Associated Press on Gaming, 2006).

Why implement gaming in secondary education, specifically technology education? Gaming has the ability to make learning entertaining for most students and increase their motivation, especially those who are identified as at-risk of dropping out of school. It can also provide quick and specific feedback that can help students succeed in many subjects, and as the authors found in their gaming studies, STEM disciplines are no exception. Games use stories, characters, and other environmental elements that produce a unique experience allowing them to later recall addressed subject matter. Bentley (2006) asserts "whereas traditional blackboard learning sees the learner as a passive recipient of knowledge, game-based learning allows … students to become an active member of their education." Henry Jenkins from the Massachusetts Institute of Technology indicates that gaming can teach systematic content much more efficiently than simply learning facts through traditional means (2008).

Research in gaming has been on-going for many years as it relates to education, but only in the past decade have we seen results that show the value gaming brings to the classroom as either a tool to learn subjects (i.e. STEM disciplines) or as a career awareness area. Current research demonstrates many facets of gaming that are useful in the integration into and enhancement of any discipline. First, no indications of undesirable behaviors or critical attitudes or values (i.e. violence and sexism) have been found at a significant level for games. Many researchers have found gaming instrumental in psychomotor development and helping students create good spatial orientation skills that are needed for many careers. Also, enhanced psychomotor coordination and relieving of stress (i.e. sports and dynamic games), and the ability to help students think and reason logically (i.e. puzzles and question type games) have been results in gaming research studies. Many instructors have found gaming and game development as a good supplement for traditional lecture. When used as a supplement, many teachers see an increase in student interest, motivation, retention, and improved higher-order thinking skills (Kritz & Hense, 2006; Prensky, 2003; Randel, al et, 1992). Considering these attributes concerning gaming in education, the authors identified the need for a two-year game art and design curriculum that relies on the attributes of gaming to provide technological literacy and 21st century skills to high school students.

Methodology

The process for developing the online attitudinal instrument pertaining to gaming began with extensive research in gaming and the use of games in education. The researchers of this study visited both professional conferences and industries related to gaming, and conducted data mining for information related to the topic. Once the background research was conducted, the authors began the process of developing the online survey instrument that targeted students and professionals within the discipline of technology education. The website's title "STEM: Gaming in Education" was used as a springboard to conduct research on attitudes toward the use of gaming in the classroom. The targeted survey instrument was developed using a variety of similar instruments used to gather information about a vast and diverse population. Research on both gaming content

and online surveys was conducted in order to properly develop an instrument for the study. Once completed, the online survey was tested and reviewed by experts in the field of survey research, technology education, and educational psychology. This allowed the authors to edit and refine the instrument before linking it to the STEM: Gaming in Education website. Once approved by the institutional review board from the university, a link from the website was activated with a security password system for participants within the study. Participants were found by posting on technology education listservs, announcements at conferences, national workshops, and by simple word-of-mouth. The online survey was completed in the spring of 2008 with over 258 participants from a variety of backgrounds, cultures, and locations.

Findings

The survey instrument collected a variety of information from its participants over a six month period that ended in the spring of 2008. A total of 258 participants volunteered to participate in the survey from 20 different states and four countries. These included participants from North Carolina, Florida, North Dakota, Georgia, Oregon, Virginia, Wyoming, Texas, Virgin Islands, Pennsylvania, New Jersey, New York, Washington, Illinois, Arkansas, Maryland, South Carolina, Iowa, Alaska, Ohio, Indiana, Brazil, Jamaica, and Guatemala. Sixty percent (155 participants) were students, 17 percent (44) were teachers, five percent (13) were parents, and three percent (9) were administrators. Fifteen percent (37) did not fill in the subject information area associated with the study. The majority (60 percent or 151) of participants that responded to the survey questions were between the ages of 14-18, male, and in high school. Table 1 shows the overall demographic information about the participants in the study.

The survey asked participants what they felt would be a good definition for gaming from a menu of items where they could choose more than one answer. Of the 258 who responded, most (77 percent or 199) indicated that gaming was in the entertainment media category; but the category of computer-video technology was a close second with 75 percent (193) selecting this category. Forty-two percent (108) of participants selected the category of gaming as an educational resource. The categories of violent and addictive were the least selected by participants; 19 percent (50) stated violent and 35 percent (90) stated addictive as part of the definition of gaming. The survey also gave participants an opportunity to give a free response; some responses included: "computer programming based on the game industry;" "you play games on the computer, phone, or outside;" "gaming is a tool we can use to enhance our student's and our knowledge of the technology at hand;" "something fun to do to kill extra time;" "usually recreational;" "having fun." The survey further asked participants how many hours per day they spend playing video and computer games. Of the 258 that responded, 66 percent (129) indicated rarely to one to two hours per day. The range for this question was from zero time spent with 19 percent (43), to 3 percent (10) indicating four to six hours spent playing games each day.

The focus of the study was to determine the value of gaming as a learning tool, especially for STEM disciplines. The results show that most participants, 74 percent (190) agreed or strongly agreed that gaming is a valuable resource and learning tool for students. Forty-eight percent (125) indicated that they have an interest in developing computer-video generated games. Seventy-two percent (187) agreed or strongly agreed that outside classroom homework assignments that use computer-video gaming development could be useful for student learning. Table 2 shows the frequencies and percentages associated with the topics on the value of gaming in education.

Demographic information about survey respondents.

Category	*Freq.*	*Percent*
Under 10 years	*1*	*0%*
11-13	*12*	*5%*
14-18	*151*	*60%*
19-22	*17*	*7%*
23-30	*11*	*4%*
31-40	*10*	*4%*
41 and over	*50*	*20%*
Male	*188*	*73%*
Female	*64*	*24%*
No Response	*6*	*3%*
Middle School	*31*	*12%*
High School	*138*	*53%*
Associate Degree	*7*	*3%*
Bachelors Degree	*31*	*12%*
Graduate Degree	*45*	*18%*
No Response	*6*	*2%*

Note: for age categories n=252; for gender and education categories n=258

Table 1

The next series of questions posed to participants in the survey dealt with using gaming to teach subject matter in STEM related disciplines. As indicated in Table 3, the majority of survey participants agreed or strongly agreed with statements that asked if gaming can be used to teach these subjects. Seventy-one percent,(183) of participants indicated that they agreed that gaming can be used in science as a way of instruction. In technology, 82 percent (210) indicated the same thing about using gaming as a way to teach technology education subject matter. Seventy-one percent(184) agreed that mathematics can be taught through gaming in the classroom. As for combining the three disciplines together in an integrated curriculum of mathematics, science, and technology education, 77 percent (199) of participants agreed that gaming can help with integrated instruction for these disciplines. Table 3 shows the survey questions and the frequency and response rate for each of these STEM related questions.

The survey asked participants about the future of games in education. The question stated, "What is your opinion on the use of computer-video gaming development; do you believe it has a future in education?" Eight-nine percent (230) of participants indicate that gaming has a future in education while 7 percent(18) indicated that gaming does not have a future in education. Four percent (10) did not answer this question. Next, the survey asked participants to give a free response about the future of gaming in education. The following is a selected sample of those responses given by the participants: "no, video games are pointless;" "if structured properly, it could be very useful to the education arena as another tool to utilize in reaching out to different types of learning styles;" "it is a way for teachers to come up with a creative way that students would enjoy to learn;" "I'm concerned about the addictive nature of the games."

In the final series of questions presented to participants, the authors wanted to know if people would support or oppose the use of gaming in education. The actual question asked in the survey was "Would you support or oppose computer-video gaming development in education?" Ninety percent (233) of participants said they would support gaming and its use in education, while 6 percent (14) indicated that they oppose gaming use in education. Four percent (11) did not answer this question. The final question asked participants for a free response on whether or not they support or oppose computer-video gaming development in education. Selected statements for this question are as follows: "video games prevent you from being physically active;" "there is so much you can learn from the environment around you instead of playing some waste of life video game;" "it would be a greatly beneficial tool if there were a way to regulate the violent content;" "students learn through hands-on activities such as gaming or building."

Data collected from survey questions about the value of using gaming in education. Gaming as a valuable resource as a learning tool for students

Category	*Freq.*	*Percent*
Strongly Disagree	*4*	*2%*
Disagree	*6*	*2%*
Neutral	*50*	*19%*
Agree	*107*	*42%*
Strongly Agree	*83*	*32%*
No Response	*8*	*3%*

I have an interest in developing computer-video generated games

Category	*Freq.*	*Percent*
Strongly Disagree	*17*	*7%*
Disagree	*40*	*15%*
Neutral	*64*	*25%*
Agree	*76*	*29%*
Strongly Agree	*49*	*19%*
No Response	*12*	*5%*

Outside classroom homework assignments that use computer-video gaming development could be useful for student learning

Category	*Freq.*	*Percent*
Strongly Disagree	*7*	*3%*
Disagree	*12*	*5%*
Neutral	*44*	*17%*
Agree	*114*	*44%*
Strongly Agree	*73*	*28%*
No Response	*8*	*3%*

Note: n for each question is 258

Table 2

Conclusions

The survey data indicates that gaming can be a useful tool for gaining and maintaining student interest in all areas of STEM education. The self-reported information provided by the participants of the study indicates that many would invite gaming to become a part of the pedagogy used in our schools and as a means to reinforce what is being taught. The discipline of Technology Education is one area that sees

this need and the authors encourage technology teachers to pursue the integration of gaming into their existing curricula. Keeping in mind that the population for this study came from targeted backgrounds in technology or related fields and had a direct interest in subjects like gaming. The researchers conclude that there is an apparent need for utilizing gaming as a vehicle for STEM subject matter delivery, as well as a motivator for students. It is a necessary instructional area evidenced by the expansion of the gaming industry and its need for an educated and skilled workforce. Therefore, more research is needed in this new and emerging area of education to develop new strategies for reaching students in the 21st century.

References

Aguilera, M.D. & Mendiz, A. (2003). Video games and education (education in the face of a "parallel school"). *ACM Computers in Entertainment*. 1(1), 1-14.

Barab, S., Thomas, M., Dodge, T., Carteaux, R., & Tuzun, H. (2005). Making learning fun: Quest Atlantis, a game without guns. *Educational Technology Research and Development*. 53(1), 86-107.

Bentley, R. (2006). http://www.personneltoday.com/articles/2006/09/19/37313/the-learning-game-using-games-to-teach.html *accessed on September 14, 2008*

Clark, A. C. (2007). http://www.ncsu.edu/project/stemgaming/index.html *accessed on December 10, 2008*

Entertainment Software Association (2008). http://www.theesa.com/index.asp *accessed on September 10, 2008.*

Feller, B. (2006). http://www.usatoday.com/tech/gaming/2006-10-17-gaming-education_x.htm website *accessed on September 10, 2008.*

Hitchcock, A.A. (2000). *Improving learning, retention of knowledge, and attitude of students in a vocational-technical college through interactive computer technology.* Unpublished practicum paper, NOVA Southeastern University, Fort Lauderdale-Davie, FL.

Jayakanthan, R. (2002). Application of computer games in the field of education. *The Electronic Library.* 20(2), 98-102.

Jenkins, H. (2008). http://web.mit.edu/cms/People/henry3/games&narrative.html *accessed on September 15, 2008*

Jenkins, H., Klopfer, E., Squire, K., Tan, P. (2003). Entering the education arcade. *ACM Computers in Entertainment.* 1(1), 1-11.

Kritz, W.C., & Hense, J.U. (2006). Theory-oriented evaluation for the design of

Data collected from survey questions about the value of using gaming in teaching STEM related disciplines.

Computer-video gaming can be used to teach students science

Category	Freq.	Percent
Strongly Disagree	3	1%
Disagree	10	4%
Neutral	50	19%
Agree	121	47%
Strongly Agree	62	24%
No Response	12	5%

Computer-video gaming can be used to teach students about technology

Category	Freq.	Percent
Strongly Disagree	1	0%
Disagree	5	2%
Neutral	31	12%
Agree	103	40%
Strongly Agree	107	42%
No Response	11	4%

Computer-video gaming can be used to teach students mathematics

Category	Freq.	Percent
Strongly Disagree	4	1%
Disagree	13	6%
Neutral	47	18%
Agree	114	44%
Strongly Agree	70	27%
No Response	10	4%

Computer-video gaming can be used to combine and teach concepts of science, technology, and mathematics education all together

Category	Freq.	Percent
Strongly Disagree	5	2%
Disagree	10	4%
Neutral	34	13%
Agree	107	41%
Strongly Agree	92	36%
No Response	10	4%

Note: n for each question is 258.

Table 3

and research in gaming and simulation. Simulation and Gaming, 37(2), pgs. 268-283.

Prensky, M. (2003). Digital game-based learning. Computers in Entertainment 1(1), pgs. 21-22.

Randel, J.M., Morris, B.A., Wetzel, C. D., & Whitehill, B. V. (1992). The effectiveness of games for educational purposes: A review of recent research, 23(3), pgs. 261-276.

Rosas, R. et al. (2003). Beyond Nintendo: Design and assessment of educational video games for first and second grade students. *Computers and Education.* 40(1), 71-94.

Schmidt, M.E. & Vandewater, E.A. (2008). Media and attention, cognition, and school achievement. *Future of Children.* 18(1), 63-85.

Vogel, J.J., Greenwood-Ericksen, A., Cannon-Bowers, J., & Bowers, C.A. (2006). Using virtual reality with and without gaming attributes for academic achievement. *Journal of Research on Technology in Education.* 39(1), 105-118.

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