# Not Always Fun and Games: Challenges to Classroom Implementation of a Serious Game

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## ABSTRACT

Many students sitting in K-12 classrooms around the world are growing up playing games that expose them to basic knowledge and skills; however, learning through gameplay is not a common instructional practice in the classroom. Technology advancements have increased the use of multimedia tools that enhance instructional content and, in many cases, empower teachers to move beyond lecture-based formats. There are some K-12 classrooms where teachers are exploring the inclusion of serious games as a mode for delivery of instruction; however, barriers need to be addressed if acceptance of the practice is to expand. These case studies involve several teachers who implemented a serious game in their classrooms, providing insights into their experiences. The participants share their views of the potential benefits, challenges, educational impact, and ideas for future development efforts for serious games. If we are to increase the use of serious games for instructional delivery it is critical that we gain a better understanding of teachers' perceptions regarding inclusion of serious games in the classroom. As with any innovation implementation, addressing stakeholder concerns is essential for successful adoption. Results from this study will benefit game developers, curriculum specialists, instructional designers, teachers, and administrators.

## ABOUT THE AUTHORS

**Jana M Willis** has worked in STEM related areas for over 30 years. Dr. Willis has a PhD. from Texas A&M University in Educational Psychology with an emphasis in Educational Technology. She is a Professor in the College of Education Instructional Design and Technology program at the University of Houston-Clear Lake and serves as Chair of the Literacy, Library, and Learning Technologies Department. In her university role she designs, develops, and implements online/hybrid courses. Her research includes online course development, project/problem-based learning, K-12 technology integration, teacher development, games in education, self-efficacy, and digital storytelling. Her interest in games in education has led to involvement in the UHCL Game and Simulation Initiative, the Annual Ed Game Expo, and involvement in the recently approved BA/MS Program in Serious Games and Simulations. Scholarly works include international, national, and regional refereed/non-refereed journal articles, edited book chapters, and professional conference presentations. Willis' service spans beyond teaching to community engagement and research, earning her the 2016 UHCL President's Distinguished Service Award. She is part of UHCL's Million Dollar Club for collaborative efforts developing interdisciplinary projects with over $1.3 million awarded.

**Monica Trevathan** is owner/founder of Curriculum & Instruction Services, LLC., specializing in STEM education curriculum and instruction and research. Dr. Trevathan has an EdD from University of Houston-Clear Lake in Curriculum & Instruction, with STEM specialization. She has served as Principal Investigator on grant funded education technology projects through Defense Advanced Research Projects Agency and National Science Foundation. She has been an educational researcher for over 10 years and holds program evaluation certification. Dr. Trevathan served as technical lead for content development with NASA's Human Research Program Education and Outreach team for 11 years where she developed K-16 curriculum aligned to the Agency's missions and objectives in STEM areas. She designed, developed, and conducted workshops for professional development of formal and informal educators in areas of human physiology in space, biology, health science.. She has 14-years' experience in private industry where she served as a project manager of education technology projects with a software engineering company. She is versed in the Software Engineering Institute (SEI) Capabilities and Maturity Model Integration practices and has managed technical projects through the entire life cycle.

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## INTRODUCTION/BACKGROUND

It is likely the career path for current and future K-12 students will involve a STEM discipline (Wang et. al., 2011). STEM, an acronym for the cross-curricular application of Science, Technology, Engineering, and Mathematics, is the foundation of 21st century learning skills (Richards et. al., 2013). Growing awareness of the critical role 21st century learning skills play in the development of career-ready students is the stimulus for growth and popularity of STEM education. However, development of K-12 students' STEM skills in America continues to lag behind other nations (Dychtwald, Erickson, & Morison, 2006; National Academy of Sciences, National Academy of Engineering, & Institute of Medicine, 2007; Salzman et. al., 2013). Concern the United States could potentially lose its technical superiority (National Academy of Sciences et al., 2007) has increased the focus on STEM education and student preparedness.

To address this challenge, innovative and engaging methods for teaching STEM are required to meet the needs of 21st century learners. Children are now born into technology and consequently, traditional instructional methods used for decades are no longer effective for the 21st century learner (Pannese & Carlesi, 2007). These methods often consist of teachers routinely providing daily lectures and textbook assignments, which offer minimal engagement and interaction. Such strategies are focused primarily on the teacher rather than the student (Heck et. al., 2000).

Using games in K-12 education for instructional purposes has become more popular in recent years due to potential positive impact on student learning outcomes (Gee, 2007, 2011; Salen, 2008). Serious games (SGs) are "explicit and carefully thought-out for educational purposes and are not intended to be played primarily for amusement" (Abt, 1970, p. 9). Furthermore, SGs have been found to be a valid pedagogical support for student learning of standards-based content (Barko & Sadler, 2013). Research studies report that SGs can "be a useful tool for gaining and maintaining student interest in all areas of STEM education" (Clark and Ernst, 2009, p.28). Computer gameplay provides excitement and cognitive stimulation for students while increasing motivation and engagement.

As early as 2005 a strong interest in the potential impact of SGs in education emerged. The National Summit on Educational Games brought together the Federation of American Scientists, Entertainment Software Association, and the National Science Foundation (NSF) to explore the crossover between games for entertainment and games for education to accelerate the development, commercialization, and deployment of new generation games for learning (Federation of American Scientist, 2005). Despite the convening of experts in the fields and research-based evidence, not all stakeholders involved in the field of learning processes have agreed with this innovative direction in teaching and learning (Halverson, 2005). As a result, research that explores the use of SGs in the classroom has been slow to develop; however, over the last decade there has been a significant growth in empirical research regarding the learning effectiveness of SGs. Boyle, et.al., provided an updated review of empirical evidence on the impacts and outcomes of SGs, which noted the most frequently occurring outcome across the studies was knowledge acquisition (2016). Recent research on educational games has been overwhelmingly positive; with evidence of significant learning improvements as compared to traditional instructional methods (Freitas, 2016). SGs are being increasingly used across multiple sectors, academic, industry, medical, and military to support education and training (Brandão, et. al., 2012; Dreimane & Upenieks, 2020; Garbaya & Lim, 2019). SGs offer interactive, immersive, realistic experiences that offer opportunity for applied learning through real case scenarios (Mohd, et.al., 2018).

### Teacher Role During Implementation

Reluctant teachers believe games offer no educational value and due to strict curriculum schedules, sufficient time is not provided to utilize SGs in the classroom (Rice, 2007). Integrating games in the classroom has produced great benefits such as enhanced student autonomy (Mifsud et. al., 2013). Other benefits include improved student self-monitoring, problem solving, increased social skills, motivation, engagement, and better short-term and long-term memory (ELSPA, 2006; Mitchell & Savill-Smith, 2004; Rieber, 1996). As such, the playing field becomes student-centered and the role of the teacher becomes a guide/facilitator to knowledge and learning. Thus, the typical role of the teacher in the instructional process requires redefinition (Mifsud, Vella, & Camilleri, 2013). Powerful learning has occurred when the classroom teacher implemented other pedagogies alongside a SG such as a field trip to a location relevant to the game (Gaydos & Squire, 2012). In this sense, the teacher became the facilitator and enhanced the student learning from the game with other learning activities. Many teachers do not understand the facilitator role (Kivunja, 2014) - highlighting the need and importance of professional development to support the application of a new technology tool such as SGs in the classroom (Stefanick, 2014).

### Teachers Who Use Games

Currently, games are being used for educational purposes by teachers who are early adopters. Early adopters realize there are neurological differences between today's students and those of previous generations and SGs are an effective media to reach the student (Schaaf & Mohan, 2014). Most early adopters are themselves "gamers" and are able to use games as a medium to meet curriculum goals (Long, 2016). These early adopters also acknowledge the need to invest time in evaluating and determining how best to use SGs: "If you stick a kid in front of the computer and expect something magical to happen, you're going to be disappointed" (Long, 2016. p. 42). In turn, teachers who do not invest time in evaluating and planning remain reluctant to embrace games for learning. Early adopters remain a small group of teachers implementing SGs in the classroom for learning purposes.

### Teacher Engagement During Development

Designing and developing a SG in isolation of educators, who possess both content and pedagogical knowledge, can negatively impact implementation and adoption due to gaps in the instructional strategies, content, and assessment elements of the SG (Linderoth & Sjöblom, 2019). Finding balance between "play" and "learning" is critical if SGs are to be adopted by teachers in the K-12 classroom. Innovation adoption and the relationship to content knowledge and pedagogical practices has been the focus of years of research in the field of education (Shulman, 1986; Koehler & Mishra, 2005); resulting in the development of frameworks such as *pedagogical content knowledge* (PCK) and *technological pedagogical content knowledge* (TPACK). In a case study by Linderoth and Sjöblom, the researchers noted "there is a need for people with the dual competence of being knowledgeable about game development while at the same time having PCK" (p. 784). Designers like the Learning Games Lab at New Mexico State University have implemented a collaborative design model that brings researchers, educators, and developers together throughout the design process, "to ensure educational goals and outcomes are appropriate for the learner and the learning environment" (Chamberlain, 2014, p. 151). The case studies in this paper followed this model during design, development, testing, and implementation.

## CASE STUDY INTRODUCTION

The Joan Ganz Cooney Center at Sesame Workshop released "Games for a digital age: K-12 market map and investment analysis" report (Richards et. al., 2013) where they defined the landscape for learning games as a continuum from short-form to long-form games. Long-form games continue beyond a single class period and can spread over weeks of game play. "Long-form games have a stronger research base than short-form games and are focused on higher order thinking skills that align more naturally with new common core standards" (p. 4). The report states long-form games are significantly more engaging and "foster motivation which keeps students involved in the learning experience" (p. 14). Each of the four case studies presented in this paper was conducted using one of two long-form SGs. Both SGs involved in the four case studies were developed by a commercial software development company partnered with an institution of higher learning. The instructional content within the SG was created as a collaboration between the software company's education and instructional technology team, university faculty from education and computer sciences, local teachers in STEM disciplines and subject matter experts from industry and government organizations. Game content was aligned to education standards from International Technology and Engineering Educators Association (ITEEA), Next Generation Science Standards (NGSS), and Common Core State Standards (CCSS) for middle school students (grades 6-8). Standards alignment was completed for Texas Essential Knowledge and Skills (TEKS) in English Language Arts and Reading, Technology Applications, and Mathematics.

The following sections highlight the education focus and game genre for the two SGs. Each SG software contained an embedded "grade book" for the teacher to monitor student progress and assess content knowledge. Educational research was conducted during implementation with the intent to contribute and advance the body of knowledge surrounding SGs in the K-12 arena. Teachers and students participated in surveys, interviews, and classroom observations. Case studies 1, 2, and 3 were conducted during pilot testing and full-scale implementation of the *Code of Aegis (CoA)* and the fourth case study was conducted during the pilot testing of *Serious Game for Energy Science (SGES)*.

**Code of Aegis**

*Code of Aegis (CoA)* was designed to teach basic engineering skills and computer programming logic using problem-solving and critical thinking (Trevathan et. al., 2016; Willis, 2014). Learning to program with robots can be challenging; students must learn not only the programming language but they must also gain an understanding of the math and physics behind robots and robotics exploration (Lau et. al., 1999; Major et. al., 2012). *CoA* capitalized on the appeal of video game play with graphic novel storytelling to engage students and to provide an easy framework for students to learn and apply English language arts, mathematics skills, programming logic, and engineering design. In-game skill-based assessments were used to complete the mission of each graphic novel chapter and to allow progression to the next chapter. The game used a 3D virtual environment for robot construction, flow-charting, code building, and three-dimensional simulation/testing, which assessed defined learning objectives. Content and assessments were developed with middle school robotics coaches, computer science teachers, and subject matter experts including robotics engineering from NASA. *CoA* development and pilot testing were funded by a Small Business Innovative Research (SBIR) joint solicitation between the U.S. Department of Education and the Defense Advanced Research Projects Agency (DARPA). Gameplay is approximately 11 hours, with an additional 4-6 hours of classroom instruction and debrief activities throughout the game. The game is designed as a long-form playable interaction that is best utilized over multiple class periods or education sessions. A researcher-constructed survey, *Teacher Perception Survey (TPS),* was developed by curriculum content experts to measure teacher perceptions regarding quality of *CoA* in terms of game utility and task accomplishment (Trevathan et. al., 2016). *TPS* measured teachers' perceptions through the following characteristics: (a) engineering process knowledge; (b) programming skill development; and (c) pedagogical strategies. The *TPS* consisted of 20 questions and utilized a five-point Likert Scale, ranging from 1 (Very Poor) to 5 (Very Good). Following survey construction, the survey was pilot tested and subjected to validation review by a panel of subject matter experts (Rubio, et al., 2003) in the fields of teacher education, technology, and assessment.


**Figure 1. CoA**


**Figure 2. CoA**

**Serious Game for Energy Science**

*Serious Game for Energy Science* (*SGES*) was funded by the National Science Foundation (NSF) through an SBIR project. It was designed to inspire students to learn about energy science, energy production, and environmental impacts through immersion in scaffolded learning within an interactive world filled with interesting characters and engaging story objectives. Using the engagement of an interactive computer-based game, *SGES* was designed to enhance math, science, environmental literacies, and


Figure 3. SGES


Figure 4. SGES

reading comprehension using problem-solving, critical thinking, communication, and collaboration skills. Students applied knowledge in a single-player or group-play format as they advanced into regional energy areas while progressing through multiple levels of learning and completing in-game assessments to complete the game scenarios.

**Case Study 1**

Case Study 1 explored implementation of *CoA* at five middle/intermediate school classrooms across four school districts located in various parts of the United States. Four teachers participated with approximately 86 students (grades 5-8). Two districts were in Texas, one in New Jersey, and one in Colorado. SG implementation occurred during the regular school day.

The *TPS* was administered to participating teachers, where findings indicated significant increases in teachers' perceptions in areas of usage and feasibility as related to the use of a SG as an instructional tool. Response analysis found 57.6% of the responses were "Good" or "Very Good.", where the most common response was "Good," with 46.3% of all responses. The least common response was "Very Poor," with only 3.8% of the responses (Figure 5). Participating teacher interviews provided a more in-depth look at areas noted as valuable by the teachers. Barriers to implementation identified during the study focused on the following themes: professional development, time, curriculum restrictions, administrative support, and reading level competencies.

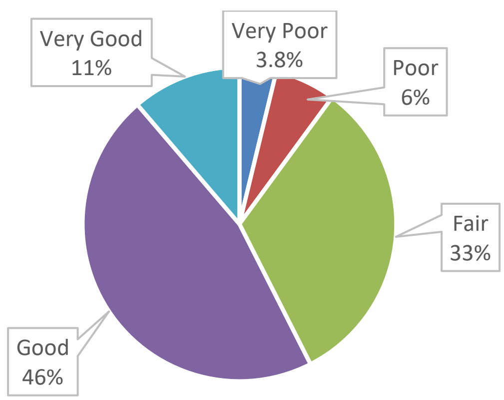


Figure 5. Teacher Perception Survey Responses by Likert Response

During interviews teachers noted *CoA* supporting materials (training videos, lesson plans with solution guides, and website) did a "Fair" to "Good" job training teachers for classroom implementation. Participating teachers identified time as the most significant implementation barrier. While the game was noted as a "fun way to introduce the topics," time commitment and return on time investment were not supported by all participants. One teacher remarked, "I do not think most teachers have this kind of time to devote to one activity unless they can seamlessly incorporate it into other aspects of their curriculum." The lack of curriculum flexibility was another significant implementation barrier. Curriculums are often developed and implemented at the district level to ensure district wide continuity and consistency. One teacher noted, "If I were still a math or science teacher, I would probably have a more difficult time fitting this in." However, despite voiced concerns, there was significant support for inclusion of a SG like *CoA* into classroom curriculum. "Having the ability to have fun while learning is what science is all about. I liked the game because it was hard and fun."

Reading level of materials included in *CoA* were noted as a significant and unexpected barrier by several participating teachers. Although reasons varied by teacher, each noted the SG reading level was challenging. The SG was designed for students in grades 6th-8th, with the overall reading level targeted at 6th grade. "Some students struggled, and I struggled a bit as to the best way to help them." All participating teachers indicated that while the storyline was excellent, and characters interesting, some words were difficult for students to understand. This was a significant challenge with one classroom where all students were deaf. This population scored lowest on both the pre- and post-assessment, which the teacher explained "students who are deaf tend to have lower reading and writing levels because for the first four to five years of life they do not have that kind of language input. When they get to school, they are already behind non-deaf students regarding reading and writing." During game implementation, this teacher noted students "would sometimes get frustrated and start clicking through a bit because of the reading struggles."

Interviews revealed teachers' believed implementation barriers could be overcome with district and administration support along with proper professional development. One teacher commented, "Technology availability in the school system is a major one [barrier], but getting administration on board to try something new is the biggest one. They tend to stay away from new ideas and push us to use the ones that we've been using for years and years." While barriers were noted, the overall teacher perceptions showed positive and favorable responses to SG implementation in middle school classrooms. *TPS* data indicated participating teachers responded positively regarding use of the SG to teach computer programming and engineering skills. Teacher interviews confirmed the SG could be an effective classroom tool. One teacher commented, "For the most part, the tasks and coding was good and well-integrated into the story. It's always hard to make those concepts real, but this was a good way to do it."

**Case Study 2**

Case Study 2 explored implementation of *CoA* on four elementary/intermediate campuses across four school districts located in the southeastern part of the United States. Each district served diverse populations of over 56,000 students, grades 6-8$^{th}$. *CoA* was implemented in all four districts: District A (AISD), District B (BISD), District C (CISD), and District D (DISD). In AISD and BISD, one technology teacher at each district and their 6-8$^{th}$ grade students were selected for participation. Two of each of the participating teachers' classes were designated as treatment groups, played *CoA* (intervention) over the course of 2-weeks during class time. A comparison group (did not play *CoA*) was created from one of each of the participating teachers' classes. In districts CISD and DISD, students participating in the district's after-school program (ACE–After School Centers on Education) were solicited to play *CoA* for a 2-week period during their after-school time. The ACE program, funded by 21$^{st}$ Century Community Learning Centers program administered by U.S. Department of Education, offered free afterschool programming to economically disadvantaged schools. Student demographics for AISD and BISD were similar across each teacher's classroom (80% Male, 50-55% White). CISD reported higher percentages of female (72.4%) and African-American (48.3%) students, while DISD reported a larger percentage of males (78.6%) and Hispanic ((75.0%) students.

At implementation conclusion participating teachers were surveyed to determine perceptions of product usage and feasibility. Results identified a disparity among teachers regarding game utility and task accomplishment. The AISD teacher (rated 95.7% of the items Good/Very Good) and the CISD teacher (rated 100% of the items Very Good) both reported much higher perceptions of *CoA* than reported by the BISD teacher (rated 56.5% of the items Poor/Fair) and the DISD teacher (rated 60.9% of the items Good/Very Good) (Table 1). This disparity could be accounted for in teacher instructional style differences, student engagement levels, and/or foundational programming/engineering knowledge. While there was a gap in teacher perceptions of *CoA* as an instructional tool, this was not reflected in student learning outcomes, which indicated students were motivated and learning occurred as a result of playing *CoA*.

Table 1. Case Study 2: Game Utility

| | **AISD** | **BISD** | **CISD** | **DISD** |
|---|---|---|---|---|
| 1. To teach concepts in the classroom | Good | Fair | Very Good | Good |
| 2. To assess learning | Good | Fair | Very Good | Good |
| 3. To enrich concepts for gifted learners | Very Good | Good | Very Good | Very Good |
| 4. To enrich concepts for struggling learners | Good | Poor | Very Good | Fair |
| 5. To increase student engagement in the material | Very Good | Fair | Very Good | Good |

During observations, there were noted differences in teaching styles and levels of project commitment among participating teachers. The BISD and AISD teachers were serving multiple roles (i.e. teacher, coach); the BISD teacher was unable to attend training due to coaching role conflicts. The evaluator reported the AISD teacher appeared to be organized, was accommodating, and attentive to efforts needed for project success. The CISD teacher, while a veteran teacher, was not "tech savvy.", which could have hindered implementation and student support. In DISD, the after-school teaching pair consisted of one retired certified teacher and one college student who taught game programming. While the college student had a programming background, the certified teacher was more passionate about implementation and pedagogically better able to provide instruction to assist struggling students.

Teachers recommended the SG not be implemented as "stand alone," but rather be used to introduce or review concepts. They noted teachers should monitor student progress/success and supplement or differentiate instruction as needed. They recommended creating the SG with different degrees of difficulty would allow for differentiation in adjusting for students' varying abilities. This outcome was supported by the BISD teacher who stated, "I think this would be a good supplemental program for my students, but I don't think I could use it in place of teacher instruction. I would have to teach the concepts first and then reinforce them with this program."

Research based instructional best practices advocate for student-centered learning involving collaborative group work. In these environments the teachers' role should be to guide and facilitate. This was expounded by the AISD teacher who said, "Teachers really have to become facilitators, observe, and monitor the needs of the students. I did not use the lesson plans [provided with the *CoA* product] because I felt it was better for the students to teach each other the skills." This same sentiment was reflected by the BISD teacher who noted, "If I were to do this again, I think I would allow my students to collaborate. By the end of our testing time I was allowing students to help one another and they seemed to really enjoy that." This was echoed by one of the DISD teachers who said, "First of all, I strongly feel after our experience that this game format would work so much better with a small group where the teacher could control student progress and monitor them well."

**Case Study 3**

Case Study 3 explored implementation of the *CoA* at two middle school campuses, from different districts, with one teacher from each campus participating in the study. Participants, selected as a purposeful sample, were veteran teachers with multiple years of experience teaching and mentoring robotics as well as self-reported high levels of comfort using technology in the classroom. Selected sites and participants bound the study with these attributes: veteran teachers, robotics teaching experience, middle school students, and the use of a long-form game. Bounding is critical in efforts to study and describe the phenomenon in depth (Merriam, 2002). This case study explored a bounded system through detailed, in-depth data collection, and from multiple sources, that provided context rich information (Creswell, 1998).

Site A (Lake) served a population of approximately 1,000 students (TEA, 2014) grades 6-8. The campus had a robust robotics program, offered as an in-school elective course and an after-school program. The program allowed student engagement in robotics competitions at local, regional, and state levels. The in-school robotics teacher, Betty, had served as the after-school robotics mentor for eight years. Previously she had been a classroom teacher for twenty-seven years teaching robotics, audio-visual, and mathematics. Site B (Park), located in a suburban area of the largest city in the state, served a population of approximately 830 students (TEA, 2014). Park offered an in-school robotics course as a science elective as well as an after-school robotics program that competed at local, regional, and state levels. Jane, with eight years of experience, served as the in-school robotics teacher and the after-school mentor; Jane had been a classroom teacher for 17 years teaching a variety of technology courses. Both schools were in suburban school districts in the largest city in the state.

At the end of the study themes were identified as a result of outcome triangulation, consisting of data collected by structured and semi-structured observations, interviews, and thoughtful reflection by the researcher. The themes were *Student Collaboration*, *Learning is Key*, and *Enabling Students*. The themes are traits of a teacher as a facilitator. With these traits, both Betty and Jane were able to easily shift to using a SG as an instructional tool in the robotics classroom. These findings suggested characteristics that make a teacher a successful facilitator could also assist teachers with incorporating SGs into their curriculum. Betty grew into the role of facilitator through her years of experience. She explained the transition, "my first year, I was like… 'Don't touch that, you'll break it!' And then, I learned that you have to allow kids to learn how they need to learn. You have to allow them to work with each other and help each other and not so much [from] me". From Betty's perspective as a facilitator, she believes "I'm supposed to teach it [content] to you. But you know what? If you have to teach it to yourself, aren't you going to remember?" For both Betty and Jane, facilitation as an instructional role transferred into gameplay interaction. While students primarily worked individually during gameplay, when help was needed, the teacher as a facilitator would ask probing and clarifying questions instead of providing students with a direct response. Students could then return to the game to investigate and problem solve.

Betty and Jane easily made the transition from their regular classroom instruction to gameplay for instruction, since their standard role was that of a facilitator rather than an instructor with traditional whole group instruction. They kept students engaged and on task by hands-on and collaborative learning. This style is also successful with gameplay as demonstrated by this study. They both recommended that when teachers are considering using games in the classroom they need to be flexible and be a facilitator rather than an instructor. Students will learn on their own during gameplay and teachers need to prepare for questions for which they may not know the answer. As a facilitator, the teacher should enable students to find the answer in a variety of ways.

**Case Study 4**

Case Study 4 explored implementation of the S*erious Game for Energy Science* (SGES) as a fully functioning prototype. The district was diverse, serving over 39,000 students. Participating students were in 5th grade and were representative of the district's demographics. Case Study 4 took place with a school district-wide gifted and talented (GT) pull-out program. Three classes of 24 students participated (control, exposure, and treatment). In the district, assessment for giftedness included using diverse evaluation methods to qualify for program eligibility. Gifted students are often predisposed to critical and higher order thinking skills, therefore enabling them to push the boundaries of the SG's design (Elder, 2007). If the SG is to be effectively used as a mechanism for scaffolding learning processes and enabling classroom teachers to differentiate learning to meet the diverse needs these boundaries need to be explored (Marzano, 2010).

Initial STEM interests of participating students were assessed using a researcher-designed survey. Students' initial critical thinking abilities were measured using the Cornell Critical Thinking Test (CCTT) (Ennis et. al., (1985). During the semester, formative data was collected using the SG's computer logs on student time-on-task, student progress, and student performance on learning goals in science, mathematics, and reading comprehension. Classroom observations were conducted throughout the semester using a semi-structured observation protocol to collect both objective and subjective data (Carspecken, 1996); engagement, student communication, and teacher instruction were focus points during the observations. Case Study 4 results showed statistically significant improvement in students' science and math content knowledge for participants in the treatment group.

Teachers who used the game indicated the game's supporting instructional tools made grading, assessment, and development of a learning plan easier than in other non-game supported instructional units. Teacher interviews, classroom observations, and student focus groups all indicated the game was engaging with a potential to be, as one student indicated "really awesome and way better than regular school stuff." The treatment group teacher noted the game held students' attention, motivated them to continue, and in pairs promoted collaboration. The treatment group teacher noted she saw so much potential for the game, because students were interested in the game even though it was not instructionally supported in the classroom. Although the small number of observations makes the data less reliable, treatment classroom students were on task 95% of the time during game play, compared with 85% of the time when engaged in non-game activities.

Teacher interviews and classroom observations indicated the game's instructional supports, in the form of built in gradebook, pre-loaded assessments, and student logs were instrumental in helping teachers track student learning. The teacher management system provided student-level data that were valuable in identifying students who may be struggling. For example, the teacher was able to perform item-analysis and re-teach to clarify concepts when needed. One teacher commented that she could easily envision how the next iteration of the game, with more gameplay, could expand the possibilities for differentiating instruction and provide real use for this item-by-item analysis of student learning.

## CONCLUSION

The K-12 education sector continues to underutilize SGs as an instructional tool in the classroom. The student population of today is growing up playing games that informally introduce them to basic knowledge and skills, creating an expectation that this is a mode of learning that would be accessible once they entered the classroom. Serious games and simulations are used for skills training and knowledge acquisition in industry and military training (Brandão, et. al., 2012; Dreimane & Upenieks, 2020; Garbaya & Lim, 2019). However, K-12 classroom pedagogy tends to reflect older practices. This disconnect calls for implementation of innovative solutions that ensure students are proficient in the 21st century skills needed to be career and/or military ready upon graduation. Schools should be preparing students for not only the workforce of today but for STEM jobs that have not yet been discovered or created.

Teachers' personalities, qualifications, and instructional styles are an important consideration during innovation implementation. Older, veteran teachers might not be as "tech savvy", and as a result need additional support prior to implementing a new program. Additionally, certified teachers may be better able to utilize the SG for learning purposes. This was clear when contrasting the after-school program teachers to the certified teachers. The retired, certified teacher integrated effective lessons to support the learning of skills and concepts addressed in the SG. The teacher used visual models and kinesthetic activities to assist struggling students. The college student, adept at teaching gaming programming, was "out of his element" and not able to implement the game as effectively. Although there were differences in instructional styles between teachers, the SG was still proven successful at improving student-programming skills and motivating students' levels of engagement to learn.

To successfully bring SGs into the classroom, teachers should be trained as facilitators of learning as opposed to instructors who deliver content. This is not only successful for game use, but also for most learning environments. Regarding gameplay as instruction, Jane (Case 3) enthusiastically said, "Using games to enhance instruction is an awesome way to get your students excited about learning!" Betty leaves us with the following advice and modeling of her role as a facilitator, with and without gameplay, "I am really big with putting my hands behind my back, and allowing them [students] to learn from each other. Not for me to go up and give them an answer. I really believe that they are going to remember more if they are doing it themselves."

Results from the case studies presented here indicated SGs have positive impacts on student learning outcomes, student engagement, and student-focused instructional practices. Findings also indicated persistent barriers to SG adoption. As with most innovations introduced in the educational system, *instructional time* continues to be a barrier to SG adoption and implementation (Ertmer, 1999; Ertmer, et al., 2012). District *curriculum restrictions*, *high-stakes testing*, and the need to align SGs to state and national standards require sufficient time for investigation. Innovations such as SGs often require teachers to invest time in training and skill development that may not align with their perceived "return" on academic advancements of their students (Baier, 2015; Like, 2013). A lack of teacher professional development training on SG implementation has been reported (Stefanick, 2014). Another barrier preventing teachers from accepting and using SGs in the classroom is the lack of in-game assessment (Zapata-Rivera et. al., 2009). Even in the SG market, most products offer neither in-game assessment nor a grading tool (gradebook) for teachers. To further complicate SG inclusion in the classroom, teachers have reported difficulties in software installation as well as infrastructure support (low band-width, sub-par graphics and computing power, etc.). It is essential teachers receive support from school administration (Walsh, 2002) and Information Technology staff when procuring SG for classroom use, installation, and addressing technical issues.

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