Exploring 21st Century Learning: Game design and creation, the students' experience

Cesar C. Navarrete, University of Texas at Austin
Laura Minnigerode, World Wide Workshop

Abstract: This research focuses on the students' perspective of learning to program educational games as observed through the 21st century skill set: Creativity and innovation learning; collaborative learning; problem solving and critical thinking. Involved in creating original digital games, students in each grade 6, 7 and 8, reflect on their experience and perspective on technology-integrated digital game learning. This study offers insight on how authentic technology integrated learning with engaging game programming experience from the student's view as well contributes to 21st century skill research. Students found the technology environment engaging learning environment that allowed for critical thinking and creative problem solving. Open-ended design and development learning approaches may inform the educational community on 21st century learning.

Introduction

Transformative technology-integrated education is the hallmark of 21st century learning that proposes a socio-constructivist, student-centered learning environment in which learner build their own knowledge and understanding through the creation of authentic digital media (Papert, 1980; Squire, 2011). Young students learning to program games engage in "active" learning, in which they can "shape the reality" as they "modify" and "build alternatives" (Papert, 1980, p. 126). Students designing and programming original games on topics of social and educational importance is argued to hold this educationally transformative potential (Caperton, 2010; Thomas, 2011). While playing educational games offers students engaging learning opportunities (Ventura, Shute, & Kim, 2012), the design and development of games provides a students greater capacity for technology integrated learning with increased learner motivation for deeper understanding through procedural learning (Shaffer, 2006). This study explores student-centered approaches in which, the student becomes the voice of experience in a creative design learning environment that may inform the research.

In an on-going, single case study on grades 6, 7, and 8 students who learned technology every day by designing and programming the games using Action Script language (Papert, 1980; Squire, 2011), the focus of this study is to understand what designing and programming digital games on educational topics of social importance affords the students in terms of 21st century skills (ISTE, 2007). Moreover, we explore curriculum approaches that develop inventive potential in young students in the development of pedagogical theory with educational technologies (Lewis, 2009).

The learning domains of interest to this investigation are creativity and innovation; communication and collaborative; problem solving and critical thinking. The research questions guiding this study are: How do students experience learning in game design and development environment in terms of 21st century skills? How do students express their understanding of creative and innovative thinking in designing and programming games?

Background literature

Digital Literacy and 21st Century Learning

Technology integrated learning suggests "new literacies" that involve complex and intricate multiple literacies with capacity to "read and write with multiple modalities" (Labbo, 2006, p. 200). Although the skills required by 21st century learners are not yet fully delineated, the extension of learning in a technology rich environment is argued to hold a vast potential (Bransford, Brown, & Cocking, 1999). Technology environments have been identified for offering learners opportunity for creative thinking in the production of digital artifacts representing understanding (Gangadharbatla, 2010). The National Educational Technology Standards for students, NETS•S, posits that creativity and innovation, communication and collaboration, research and information, critical thinking, digital citizenship, and technology operations are critical to learners (ISTE, 2007). In game creation, students are using technology to build a digital entity rather than as information delivery system is significant.

This technology-integrated, project-based, constructivist learning approach is significantly different than the current standards-based and offer opportunities for alternative to the "knowledge-storehouse" approach entrenched in current educational systems (Sternberg, 2012, p. 208). Therefore, in understanding digital literacy, in terms of 21st century skills, creativity and higher-order thinking are pivotal constructs to and for the purpose of this paper, "thinking and problem solving that involves the construction of new meaning" (Runco, 2008, p. 96) offers the research lens to this study. Moreover, the need to transform educational approaches that align with the teaching of creativity is argued (Kaufman & Sternberg, 2010) with the understanding that "to succeed in today's world, one also needs to be able to think creatively" (Sternberg, 2012). Therefore, foundational understanding of these digital literacies with the focus on the development of creative thinking is urgently needed.

Foundations of Games and Play

In addressing the question of why game design curricular approach is important to learning, the cultural implications must be reviewed. The sociocultural implications of games and play in culture are deep and long-standing (Huizinga, 1950). Games and play, in general, have been identified as fundamental to socio-cultural dynamics and important to the development of civilization (Caillois, 2001). Games are intricately associated with social development in cultures worldwide and play is a global phenomenon. While games encompass an innumerable variety of objectives, they may be categorized into four main rubrics: agon, alea, mimicry and ilinx, (p. 12). These four elements may be found in digital games corresponding to competition, chance, simulations and "pursuit of vertigo" (p.23) via virtual illusions. Epistemic understanding of these games may offer substantial insight into the pedagogical significance of game play (Gee, 2005; Shaffer, 2006; Squire, 2011). That is, the educational value of games and play is important to game creation and may be understood as focal to the design of games and distinguishes itself from the privileged educational forms that focus on the 'seriousness' of traditional educational perspective. Thus, game creation, as a learning approach has distinct applications and calls for empirical study.

Game creation

Digital game design and development as a learning environment suggests an added tier of complexity as it extends the students capacity to not only learn the content in the game but metacognitive engagement is posited (Robertson & Howells, 2008). Creating and programming games is central to the development of technology literacy similar to the way the writing supports traditional text-based literacy (Caperton, 2010; Kafai, 2006). In a study on a high school computer programming class, student game design and programming projects offered insight into the 21st century learning (Thomas, 2011) with findings identifying an inherent "gaming culture" that provided a connection to the learners and provided for learner motivation in an immersive game programming class (p. 405).

While digital game design with simplified game development software has been a subject of previous research (Baytak & Land, 2011), this study responds to the critical need to understand the complexity of programming in this project-based environment. In an eight-week game authoring exploratory study involving 30 students, ages 9-10, researchers found that game authoring opportunities offer students motivating, technology-supported learning activities that promote enthusiasm and empower young learners through creative expression (Robertson & Howells, 2008). Moreover, digital game design has been found closely associated with system-based literacy (Walsh, 2010) inherent in digital literacy. While related studies examine the constructs investigated in this study (Baytak & Land, 2011; Reynolds & Caperton, 2011; Robertson & Howells, 2008; Thomas, 2011) a gap remains in understanding the learning implications for students who work on designing and programming games in middle school as a regular technology course. What and how the students are learning in full-year, regular classroom based instructional settings and what this learning means in terms of 21st century skills are key to this report. Therefore the aim of the investigation is to answer the research question: How do students learn technology literacy in game design class? While the literature suggests learning benefits for students, empirical study of game design and development for learning critical digital literacy skills is called for.

Methods

Study context

Students enrolled in the school program are 83% Hispanic and 13% African American. Approximately 40% are English language learners. In this school, 93% of the students were of a low-income demographic group with 93% qualifying for free or reduced lunch. In the game design class, teachers use a student-centered approach of guiding students to find answers for their questions about their game-topic, among their peers and using available virtual resources, including live and asynchronous expert helpdesk and tutorials, rather than direct teaching, giving students an opportunity to develop research and problem solving skills. Students involved in this study work on games every day during the whole school year, giving the grade 8 students 3 years of Flash Action Script programming experience. For example, students in grade 8 had been in the technology design environment for three school years of an hour per day participating in game design learning. Each day they do hands-on work in the process of design and development that includes in-depth research of a topic, writing on a blog, keeping a learning log, maintaining a collaborative design document on a wiki. Students also upload their work to the wiki each day. The students work together to create an educational interactive web game to teach other students about the topic. For developing the game, the students use Flash software with Action Script. The platform also makes use of ubiquitous

open-access resources that students can access through program specific wikis, such as video tutorials, as well as free use sites such as Google docs and blogger.

In this curricular design the Facets of Game Creation include, Learning platform as a transformative social media-learning network; Six learning capacities: design and programming of games; the use of project management in a Web 2.0 environment; learn in a socio-constructivist approach; use information based systems that feed into the design and programming; and the use of websites and applications to inform the design and development process (Caperton, 2010). While this curriculum may be used in different ways, in the present case the students learned these through a stand-alone technology class everyday for an hour every school day.

Data collection and analysis

This case study is primarily informed by the student interviews and triangulated with student digital artifacts as well as classroom observations. One individual interview was conducted near the end of the school year during which the students responded to a series of questions, Please see the Appendix A for an example of the interview questions. A follow-up interview was conducted with each student approximately 6 months later in which the student's game was demonstrated, reviewed, and discussed. Following institutional review board protocol in conducting the research, individual student interviews, classroom observations and student digital artifacts, in the form of screencasts of the games were analyzed to inform this investigation for the triangulation of the data sources. The names of the students are changed to pseudonyms for confidentiality of the study participants. The classroom observations and student artifacts were used to triangulate in revealing convergence, inconsistency or contradiction in the evidence (Mathison, 1988). The two teachers taught a curriculum spanning 6 to 8 grade level programming as primary component of the game authoring and the associated media development. One teacher, who taught grade 6 and half of the grade 7 students, works in a lab with traditional desktop PCs the other teacher, who taught the rest of the grade 7 and all of the most advanced, grade 8, was in a portable building with laptops.

The four students from each grade level were selected by the teachers for the ability to speak of their experience. The student selection was based on the understanding that they reveal the "emerging worldview of the respondent and to [determine] new ideas on the topic" (Merriam, 2009, p. 90). The scope of the research attempts to illuminate on the phenomenon as the "atypical" and attempt to reveal "deeper causes behind a given problem" (Flyvbjerg, 2011, p. 306). The focus of the interviews was intent on engaging the students in reflecting on their experiences the game creation. From an epistemological perspective, the researcher's knowledge and work with Flash action script and understanding coding and technical difficulties offers a distinct research lens for investigating this phenomenon. Study limitations include the self-reported nature of the information and complexity of a defining the factors involved in the analysis.

The classroom experience was observed on multiple occasions in order to triangulate with the student's experience. Notes were taken throughout the lessons and expanded immediately after for a full account of the observation. The observations transcripts were analyzed with open coding of the salient themes using the constant comparison method (Marshall & Rossman, 2011; Strauss & Corbin, 1990).

Findings

The themes revealed the learning integrated technology through the use of graphics, Internet resources and productivity software. The students learned content such as math through the coding as well as social studies and science through content they researched and integrated into game play within games. The language-arts learning was included throughout the class for reading and writing in the development of game elements as well as reflection blogs. The classrooms were student-centered as the students were presented with steps for coding sequence and then were allowed to freely manipulate and explore the interactions and effects. The students worked with partners or independently while the teacher provided support as needed. There were some differences between the two observed classrooms such as that one was a large space with 30 desktop computer stations, the other game design classroom was in a portable building and had 25 laptop computers on conference-type tables. The classroom learning verified the student interviews for convergence of evidence.

The student games were uploaded onto a secure wiki and available for play. Example screen images from the games created by the students in this study are found in Appendix B. The game artifacts also offered a convergence in evidence on game creation. While games varied in topic, functionality and gaming focus, the students were distinctly engaged in game design and development.

Creativity and innovation learning experience

In designing and programming the games, the students found a distinct space for creative thinking in working to develop a cohesive and meaningful understanding of the topic so as to create a functioning game that addressed a social issue. All 12 of the students describe the creation of games as enjoyable or satisfying accomplishment. For example, Carlos, grade 6, was succinct with his perspective on designing games, "I'm happy." The students found creating the games a meaningful and positive experience that was 'fun' despite the challenges involved in learning the topic as well as creating a functioning game. For example, Antonio expressed his positive experience in creating games, "Pretty amazing! I didn't know I could do this in middle school… it was pretty cool doing this."

The students demonstrated a deep understanding of the social issues in the creative process. For example, Blanca a grade 8 student with 3 years of programming, spoke of her understanding of polar bear environmental issues, "It's an environmental problem, how it's affecting, not just us but animals and the rest of the world." In describing her experience, she reflected, "I felt good, I felt a lot smarter." In another example, Sonya, a grade 6 student, indicated her positive experience, "The creative side is that you get to make it the way you want it. So, it can be your personality into your own game."

Communication and collaboration experience

The students normally worked in pairs on game design and development projects. The students found opportunities to communicate and collaborate on the projects during class. Although most students said that the communication and collaboration occurred in the design class, some students found the need to communicate and collaborate on the game design outside of the class. Antonio, grade 7, related that discussions about game creation

went beyond the class and talked, “Sometimes at lunch” and admitted to participating in discussions on Facebook. In another example, Tony shared his insight on the benefits of his collaboration, “We have groups to create games…it’s actually pretty good cause you need to research something but you can’t do research and do your work at the same time, so it pretty good that you stay with the group cause one person can help research and the other one might be doing the [design] work.” Blanca, also a grade 8 student, elaborated on her collaboration experience, “If I know the person, yeah, I would ask them for help with a problem, then ask them if [she] could help me with something.”

Similarly, Justin described the collaboration within his team, “It’s pretty hard getting the codes in but you have a team mate, that’s so you can pretty much work together and that helps you out in working together as team with other people and building up your [game].” Justin, also a grade 8 student, describes his collaboration experience, “It’s pretty easy sometimes when you got a partner that you work well with, like my partner, we worked on a game, twice, so we still have our ups and downs, it’s pretty easy to resolve our stuff.” However, not all students found collaboration a positive experience. For example, Julia in grade 7, said of her collaborative experience, “It’s difficult…Especially when you have ideas and they want one thing and you want another but you’re all sharing a game so you have to do ‘eni, mini, mo’ and then sometimes you don’t get what you want and other times you do and it’s really unfair when you do all the work.” Indicated by the discussion, the students had mixed results on the collaboration that may play into other constructs such as creativity and innovation.

Problem solving through creative and innovative thinking experience

The students were able to solve problems in both design work as well as the programming aspects of the game creation. While much of the codes are openly accessed through wikis, the student must still be able to use the codes for their own unique purpose in the original game. Moreover, the students were able to leverage information resources as well as collaborate in working through the challenges of game design and development. Problem solving skills were used throughout the design and development process, from identifying the specific topic, research, design of digital objects and programming the Flash games.

In describing the complexity of programming the games, Blanca, a grade 8 student, spoke of her understanding, “It makes me understand how the computer talks and how it’s different from, let’s say our language, how the computer has its own language and we have ours.” Tony, in grade 8, said of his experience with solving problems with the programming, “It makes me feel pretty good that I figured out what my problem is, the problem solving [the] game by yourself.” In grade 6, Todd offered his experience with problem solving, “It helps your problem solving skills on how you want to, if something doesn’t work on the code or something, you look throughout the code to see if you’ve made any mistakes or anything like that.” Blanca also expresses her problems solving experience, “It makes me feel more confident in myself. I could get over a problem and solve it.” Arguably, the construct of problem solving is difficult to isolate from creative thinking and collaboration in the design environment. Therefore, these constructs may overlap.

Overall, the students found the game design and programming an enjoyable experience despite the challenges involved in research, collaboration and programming. Students shared a positive response on their experience with introspection and candor in the interviews.

In answering the question: How do students experience learning in game design and development environment in terms of 21st century skills? The students working on game design and programming were immersed in open-ended creative work in which they collaboratively solved problems. They were able to research information and determine the essential elements to integrate into their educational game. Importantly, the student found the coding a challenge but managed to find success in this learning environment as a form of 'hard fun' (Papert, 1980).

In responding to the question: How do students express their understanding of creative and innovative thinking in designing and programming games? The 12 students in the study were consistent in describing their creative efforts as fulfilling and described learning about their research topics and going considerably deeper than traditional classroom coverage of a subject (Shaffer, 2006; Wiggins & McTighe, 2006) for greater understanding of the topic. They described the creativity involved in the process as both challenging and fun (Papert, 1980). The level of satisfaction was notably evidenced through the students' description as enjoyable learning in a traditional school environment. The positive tone along with the expressions of satisfaction and fun correspond with the literature on the correspondence of creativity learning with emotion (Root-Bernstein & Root-Bernstein, 1999; Spendlove, 2008).

Discussion

Creative and innovative thinking was identified in the interviews associated with positive feeling of accomplishment as student found satisfaction in being able to create a game and solve the coding problems (Baytak & Land, 2011; Reynolds & Caperton, 2011; Robertson & Howells, 2008; Thomas, 2011). Creative thinking is framed as the everyday experience of problem-solving creatively (Runco, 2008). In the open-ended, student-centered design environment, students were afforded opportunity for individualized and personally fulfilling creative experience. Critical to this understanding, the connection of creativity with emotions corresponds with the literature (Root-Bernstein & Root-Bernstein, 1999). The concepts related to the creative process include the understanding that creativity may be directly associated with the human emotional process (Csikszentmihalyi, 1996). Moreover, imagination is important to this construct involved in creativity (Root-Bernstein & Root-Bernstein, 1999) that is exemplified with Julia's reflection on her creative process, "When I'm making a game, it makes me feel I'm imagining something like if I'm in a world of imagination or I'm asleep and I'm dreaming." The findings of student enjoyment of difficult tasks aligns with foundational concepts stemming from active learning (Dewey, 1910; Vygotsky, 2004). While active learning has been associated with physical environments, the underlying principles of active learning may be found in immersive technology-integrated learning (Papert, 1980). That is, active learning in not a physical activity but rather that the students are "active builders of their own intellectual structures" (p. 19) and not just recipients and assimilators of facts.

In creating learning games, the students must work independently to research information and develop a deep understanding of the topic so that can be 'modeled' through the game. In this technology-based environment, the students must develop a substantial and reliable understanding of the complexities in a social issue to create a

game. This suggests that students in game design and development must look to "underlying causes and deep explanations" (Wilensky & Reisman, 2006, p. 187) in order to construct a game that reveals the important aspects of the topic address. Essentially, the student builds an interactive model, in the form of a game, which may involve a level of embodied modeling. This understanding of student-centered learning approaches posits game design learning as educational instructional design for authentic learning as nascent game designers and programmers. Exemplifying this process, Sonya, a grade 6 student reflected on this "deep" learning, "Like when it's supported by facts, more facts will help me so I can get a better understanding and maybe help the game player kid understanding it." Similarly, Alma, a grade 8 student, also reveals her learning experience, "When creating the game you have to think about the social issue." Blanca also adds about her deep learning experience, "It helped me learning about the environment by, because, I didn't know that CO2 would affect the whole world." Indeed, a student must have considerable understanding of the critical issues in order to create a digital game that illustrates the learning of the topic at hand and may suggest this learning as a form of embodied modeling approach (Wilensky & Reisman, 2006).

Critical to the game design and programming process is the integration of varied subject within the scope of the game. That is, science, social studies, language arts, and math may be included within the game design project for holistic learning in contextualized environments (Papert, 1980). For example, in grade 7, Julia describes this content confluence, "All of this code and stuff is based on spelling and English and math. We use math in the code using the numbers, so that it goes to the exact point that you want it to be and then we [learn] science because of gravity and the velocity, so all of the subjects pretty much go into game." Deep understanding and connecting ideas may be suggested in this as a critical component of thus curricular approach.

The findings offer a distinct view into the game design and development environment as indicated by four students from each grade level. Besides the capacity for engaging students in learning through digital media, game design extends the learning potential in deeper and richer ways (Gangadharbatla, 2010; Hobbs, 2011). Moreover, with the critical scarcity of technology integrated learning with ELL students (Padrón, Waxman, Yuan-Hsuan Lee, Meng-Fen Lin, & Michko, 2012), significant learning benefits may be gained (Cummins, 2000). Game design activities may support interactive technology learning environments in which learners can create their own rich understanding through a student-centered learning approach (Reynolds & Caperton, 2011; Robertson & Howells, 2008; Thomas, 2011). Further investigation through the development of a survey based on 21st century skills may offer greater insight into the game design environment as an open-ended learning space.

Conclusion

While creativity and innovation learning remains an illusive construct, especially if this understanding is based on traditional curricular approaches centered around declarative knowledge and does not marginalize the importance of procedural knowledge (Papert, 1980; Shaffer, 2006). Root-Bernstein and Root-Bernstein (1999) offer critical guidance into understanding of creative thinking with their focus on the elements of imagination, observation, imaging, abstracting and so on, as different from established arguments that relate it to intelligence constructs (Ambrose, Cohen, & Tannenebaum, 2003). That is, a learner does not have to demonstrate greater degrees of intelligence to be creative with technology. Critical to the research, "creativity is something we can find

in every child" (Runco, 2008, p. 96). It is the individual who identifies his or her own creative potential. Creative thinking is argued as better understood in terms of the learner's self-perception in a socio-cultural context. Moreover, Gangadharbatla (2010) argues that technology-rich environments provided further learner capacity to expand creative potential as an innovative form of socio-cultural expression and participation.

The complexity of integrating multiple-disciplines within a learning framework leaves many questions unanswered: How do we measure the learning in these complex, open-ended approaches? How do we prepare teachers for teaching the 21st century skills? Nonetheless, inroads into transformative technology integrated learning demands investigation for empirical understanding for informing K-12 curricular design.

Specific to the students who participate in this study, 100% of the 25, grade 8 students in the school who had been learning game design and development for 3 years passed the state algebra end of course exam with a minimum of satisfactory (level 1). Both Tony and Justin scored, recommended (level 2) while Blanca scored advanced (level 3). Additionally, both Blanca and Justin were ELL students who had been exited out of the English as a second language program. While no causal implications are ascribed to the 100% percent passing rate on the state end of course exam in a 98% low-income demographic population, the game design and programming learning may posit a learning approach that supports standards-based learning as an incidental result of the creative, and immersive open-ended learning approach.

Future Research

Further research on game design and development will continue to aggregate greater understanding of this type of educational space and what implications it hold for transformative technology-integrated learning. Development of a survey designed to capture students' perceptions is in process so as to include a broader scope of understanding of the learners' experience in open-ended technology-based learning. Moreover, we argue for opening discourse on how else we may evidence the learning. For example, educational data mining approaches may offer additional evidence of student meaning making in complex "open learning platforms" (Levy & Wilensky, 2011, pp. 558–559). While traditional scientifically based research methods offer a specific understanding of the learning, how the students interact with technology systems may shed light on open-ended learning approaches.

References

Ambrose, D., Cohen, L. M., & Tannenebaum, A. J. (Eds.). (2003). *Creative intelligence : Toward theoretic integration*. Cresskill N.J.: Hampton Press.

Baytak, A., & Land, S. (2011). An investigation of the artifacts and process of constructing computers games about environmental science in a fifth grade classroom. *Educational Technology Research & Development*, *59*(6), 765–782. doi:10.1007/s11423-010-9184-z

Bransford, J., Brown, A. L., & Cocking, R. R. (Eds.). (1999). *How people learn: Brain, mind, experience, and school*. Washington D.C.: National Academy Press.

Caillois, R. (2001). *Man, play and games*. Urbana: University of Illinois Press.

Caperton, I. H. (2010). Toward a theory of game-media literacy. *International Journal of Gaming and Computer-Mediated Simulations*, *2*(1), 1–16. doi:10.4018/jgcms.2010010101

Csikszentmihalyi, M. (1996). *Creativity: Flow and the psychology of discovery and invention* (1st ed.). New York: HarperCollinsPublishers.

Cummins, J. (2000). Academic language learning, transformative pedagogy and information technology. *TESOL Quarterly*, *34*(3), 537–548.

Dewey, J. (1910). *How we think*. Boston: D.C. Heath & Co.

Flyvbjerg, B. (2011). Case study. In N. Denzin & Y. Lincoln (Eds.), *Handbook of Qualitative Research* (pp. 1001–1017). Thousand Oaks, CA: Sage Publications.

Gangadharbatla, H. (2010). Technology component: a modified systems approach to creative thought. *Creativity Research Journal*, *22*(2), 219–227. doi:10.1080/10400419.2010.481539

Gee, J. P. (2005). Good Video Games and Good Learning. *Phi Kappa Phi Forum*, *85*(2), 33–37. doi:Article

Hobbs, R. (2011). Empowering learners with digital and media literacy. *Knowledge Quest*, *39*(5), 12–17.

Huizinga, J. (1950). *Homo Ludens: a study of the play element in culture*. New York: Roy Publishers.

ISTE. (2007). *National educational technology standards for students : Connecting curriculum and technology / International Society for Technology in Education.* (2nd ed.). Eugene, OR: International Society for Technology in Education.

Kafai, Y. B. (2006). Playing and making games for learning instructionist and constructionist perspectives for game studies. *Games and Culture*, *1*(1), 36–40. doi:10.1177/1555412005281767

Kaufman, J. C., & Sternberg, R. J. (2010). *The Cambridge handbook of creativity*. Cambridge: Cambridge University Press.

Labbo, L. D. (2006). Literacy pedagogy and computer technologies: Toward solving the puzzle of current and future classroom practices. *Australian Journal of Language & Literacy*, *29*(3), 199–209.

Levy, S. T., & Wilensky, U. (2011). Mining students' inquiry actions for understanding of complex systems. *Computers & Education*, *56*(3), 556–573. doi:10.1016/j.compedu.2010.09.015

Lewis, T. (2009). Creativity in technology education: Providing children with glimpses of their inventive potential. *International Journal of Technology & Design Education*, *19*(3), 255–268. doi:10.1007/s10798-008-9051-y

Marshall, C., & Rossman, G. B. (2011). *Designing Qualitative Research* (5th ed.). Los Angeles: Sage.

Mathison, S. (1988). Why triangulate? *Educational Researcher*, *17*(2), 13–17.

Merriam, S. (2009). *Qualitative research: a guide to design and implementation*. San Francisco: Jossey-Bass.

Padrón, Y. N., Waxman, H. C., Yuan-Hsuan Lee, Meng-Fen Lin, & Michko, G. M. (2012). Classroom observations of teaching and learning with technology in urban elementary school mathematics classrooms serving English language learners. *International Journal of Instructional Media*, *39*(1), 45–54.

Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas*. New York: Basic Books.

Reynolds, R., & Caperton, I. (2011). Contrasts in student engagement, meaning-making, dislikes, and challenges in a discovery-based program of game design learning. *Educational Technology Research & Development*, *59*(2), 267–289. doi:10.1007/s11423-011-9191-8

Robertson, J., & Howells, C. (2008). Computer game design: Opportunities for successful learning. *Computers & Education*, *50*(2), 559–578. doi:10.1016/j.compedu.2007.09.020

Root-Bernstein, R., & Root-Bernstein, M. (1999). *Sparks of genius: the thirteen thinking tools of the world's most creative people*. Boston Mass.: Houghton Mifflin Co.

Runco, M. A. (2008). Creativity and education. *New Horizons in Education*, *56*(1), 96–104.

Shaffer, D. (2006). *How computer games help children learn* (1st ed.). New York: Palgrave Macmillan.

Spendlove, D. (2008). The locating of emotion within a creative, learning and product orientated design and technology experience: Person, process, product. *International Journal of Technology and Design Education*, *18*(1), 45–57.

Squire, K. (2011). *Video games and learning: Teaching and participatory culture in the digital age*. New York: Teachers College Press.

Sternberg, R. J. (2012). What is the purpose of schooling? In D. Ambrose & R. J. Sternberg (Eds.), *How dogmatic beliefs harm creativity and higher level thinking* (pp. 207–219). New York and London: Routledge: Taylor and Francis Group.

Strauss, A., & Corbin, J. (1990). *Basics of qualitative research: Grounded theory procedures and techniques*. Newbury Park Calif.: Sage Publications.

Thomas, M. K. X. G. (2011). Fostering 21st century skill development by engaging students in authentic game design projects in a high school computer programming class. *Journal of Educational Computing Research*, *44*(4), 391–408. doi:10.2190/EC.44.4.b

Ventura, M., Shute, V., & Kim, Y. J. (2012). Video gameplay, personality and academic performance. *Computers & Education*, *58*(4), 1260–1266. doi:10.1016/j.compedu.2011.11.022

Vygotsky, L. S. (2004). Imagination and Creativity in Childhood. *Journal of Russian & East European Psychology*, *42*(1), 7–97. doi:Article

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

Wiggins, G., & McTighe, J. (2006). *Understanding by design* (Expanded 2nd ed.). Upper Saddle River N.J.: Pearson Education Inc.

Wilensky, U., & Reisman, K. (2006). Thinking like a wolf, a sheep, or a firefly: Learning biology through constructing and testing computational theories—an embodied modeling approach. *Cognition and Instruction*, *24*(2), 171–209. doi:10.1207/s1532690xci2402_1

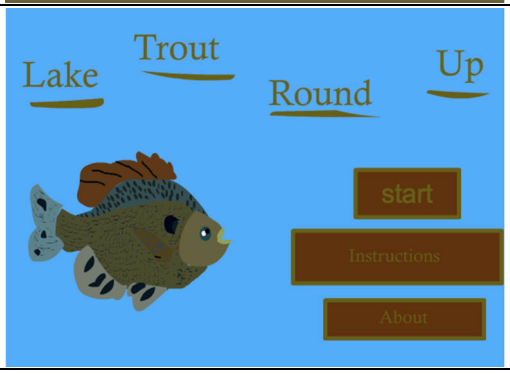
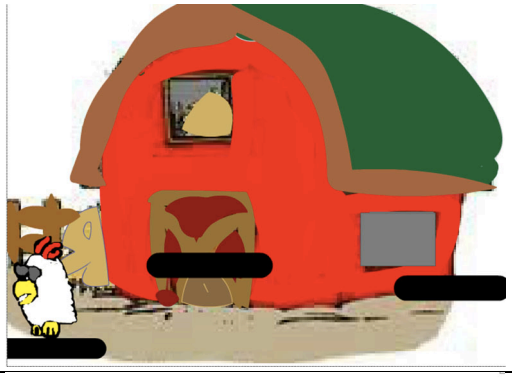
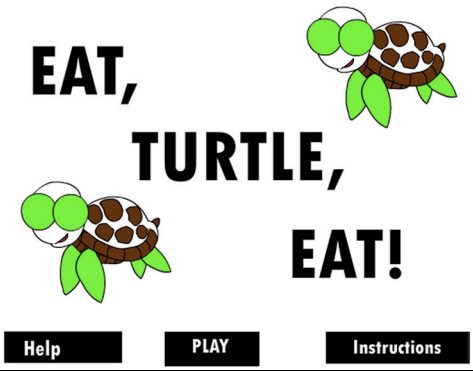
Appendix A

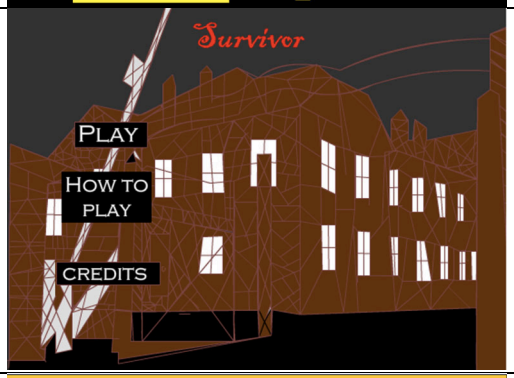
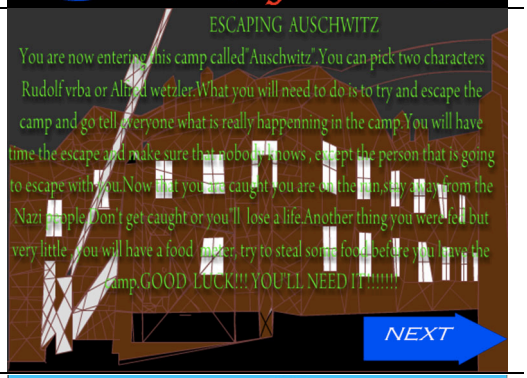
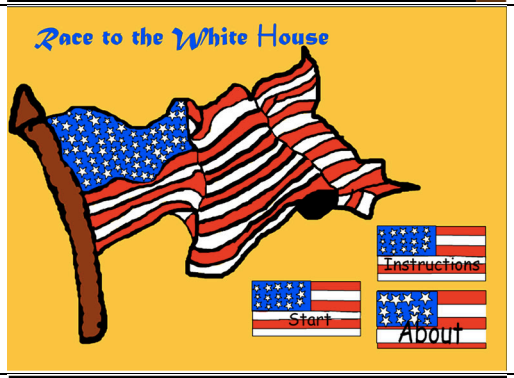
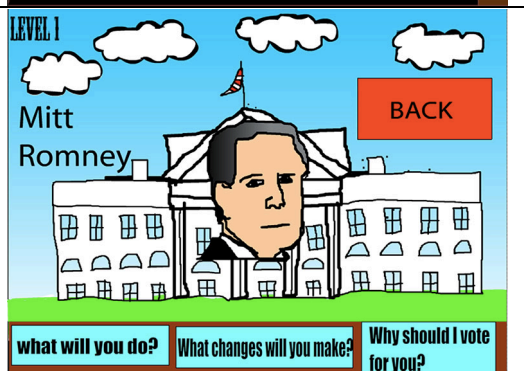
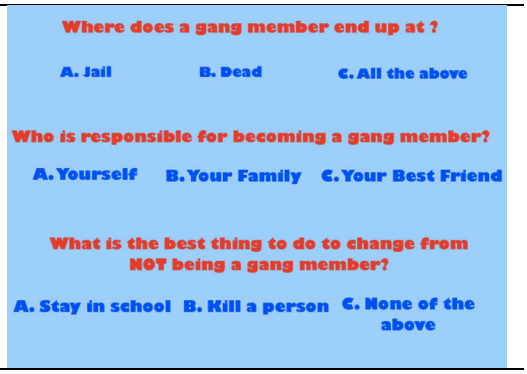
Game Design Student Interview Questions:

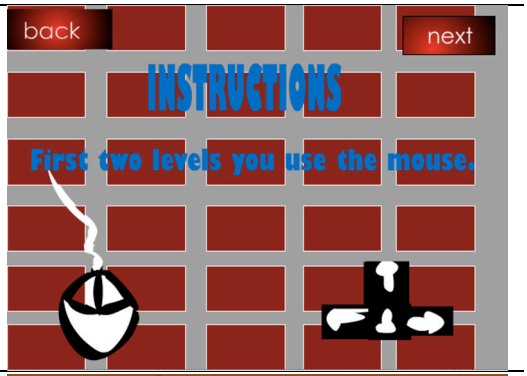
How many years have you been learning game design and development?
Tell me about your experience with designing games.
How do you feel about designing games?
How do you think designing games help you learn? (What do you learn?)
In researching for the game, how do you decide what information is useful in designing games?
How do you learn new things from playing other people's games?
What do you think about working and collaborating with others in designing games?
How do you communicate, share ideas with other students about design?
What is helpful when you design your own games?
What is difficult about designing games?
How do you think that learning action script code is valuable?
What is something new or creative that you have learned about designing games?
Compared to regular classes, how is the game design class different?
Can you tell me more about you experience in designing games?

Appendix B

Screen images of the student created games illustrating the player interface.

Student and Game title	Index image	Game image
Carlos The Undead Nightmare-cleaning the teeth: Dental hygiene issue		
Carol & Todd Lake Trout Round Up: Endangered trout issue		
Sonya Save the Chickens: Animal cruelty social issue		
Antonio Eat, Turtle, Eat: Environmental pollution issue		

Jesse & Yvonne Young Wild & Free: Gang resistance issue		
Julia Survivor: Interactive narrative of a holocaust survivor		
Alma Race to the White House: Interactive on the presidential race		
Blanca Don't Join Gangs: gang awareness and resistance issue		

Justin Street Wars: Gang graffiti and resistance issues		
Tony Help Haiti: Medical needs in Haiti disaster issue