Contribution of Intrinsic and Extrinsic Motivational Orientations to Student Outcomes in a Discovery-Based Program of Game Design Learning and Digital Literacy Development

Abstract

This paper explores contributors to student learning outcomes within a pilot program of game design learning with middle, high school, and community college students throughout the state of West Virginia. We explore contribution of student demographics and active program work to learning outcomes, especially given the program's discovery-based context. We also explore the contribution of students' intrinsic and extrinsic motivational orientation to outcomes. If motivational orientation is predictive, then self-determination theory and individuals' regulation style may have specific relevance to active processes of digital participation and digital literacy learning. Results indicate just such a relationship; intrinsic orientation contributed positively to student outcomes; extrinsic orientation contributed negatively. Findings have implications for the local implementation, towards needed improvements in the program design, and also more broadly, if learning processes occurring in this program are generalizable to other novice users encountering access, opportunities, and expectations to engage in digital participation.

Introduction

Scholarly research has begun to find evidence that important cultural and political activity is occurring in online environments, and participation requires a certain level of digital skill and knowledge of those who are active. Mossberger, Tolbert, and McNeal state that "information technology... has assumed a secure place today in the civilized life and prevailing standards of U.S. society" and that "the internet has the potential to benefit society as a whole, and facilitate the membership and participation of individuals within society" (pp. 22 and 33). Jenkins (2009) discusses participatory online culture as a growing influence, describing it as "a culture with relatively low barriers to artistic expression and civic engagement, strong support for creating and sharing one's creations… and some type of informal mentorship whereby what is known by the most experienced is passed along to novices . . . in which members believe their contributions matter, and feel some degree of social connection with one another" (p. 5). However, while he describes the barrier to entry as relatively low, Jenkins' work also emphasizes the "participation gap" -- a problematic issue of unequal access to the opportunities, experiences, skills, and knowledge that can prepare youth for full participation in knowledge based socio-political economies (2009). Hargittai & Walejko (2008) similarly find that creative activity and content sharing online is positively related to a person's socioeconomic status as measured by parental schooling, which provides empirical support for the participation gap.

Given the links between digital knowledge, and capacity for active participatory engagement in politics and culture, some concerned with media literacy, equity and education have been developing educational programs and digital literacy interventions that can serve to introduce under-represented and disadvantaged young people to activities that can improve access, awareness, and knowledge, creating opportunities and experiences to help stem the effects of the digital divide. One such program is occurring presently in the state of West Virginia.

Exploration of student engagement within this state-wide intervention, and student learning and digital literacy development in its context can not only lead to improvements in the educational program and student participants' direct, applied opportunities, but can also provide the scholarly community with greater insights on the processes by which novices become activated as participants in online digital cultures. Such research can help identify qualities and traits in individuals that may contribute to the likelihood of their active engagement, and subsequent successes or failures. Research on learner processes in the context of innovative digital literacy interventions has arguable claims to generalizeability with regard to the political and cultural engagement that occurs naturalistically among those who opt into online participatory cultures, to the extent that the digital literacy classroom offers those with previously very little affordance, with new opportunities, allowing the researcher to observe and measure the learning that unfolds. It is difficult to track such processes in the general population. Such research can therefore lend insight into the behavior of those who choose to engage naturalistically and organically given digital affordances they encounter in the world. Digital literacy intervention research offers insight into possible individual difference variables, learner processes and other variables at multiple levels of analysis (from the design of the physical and virtual environments, to the teams of young participants, to the individual human participants) that might help further explain what happens (and can happen) given the growing ubiquity of digital affordances.

Therefore, this paper explores some of the contributors to student learning outcomes within a five-year pilot program of game design learning being conducted with middle school, high school, and community college students throughout the state of West Virginia. Here we explore the ways in which student active work in the program contributes to their learning outcomes, in the context of this program that embodies a discovery-based co-learning model in which students and educators learn together as a social learning system in which students interact with peers in class, with a wiki-based e-learning environment and tutorials, and with outside expert support, especially given local educators' own learning curve in the program activities. Here, we explore in particular, the ways in which students' motivational orientation on a continuum of autonomous self-regulation to controlled self-regulation (Ryan & Connell, 1989) -- may be predictive their success. If such a motivational orientation is predictive of outcomes, then it appears self-determination theory from which such measures originate, and the type of regulation style an individual holds may have specific relevance to active, participatory engagement in digital culture, and, the design of improved supports in environments that seek to cultivate active use. The implications of this research are significant given that online digital participation is becoming an expected societal norm and practice.

Theory

With the advent of interactive and networked tools for game-making and "game-modding" (commercial games that are customizable), the capability now exists for designers of all ages to actively create and distribute interactive web games online. Computational game *making* activity by young learners has been investigated previously in educational research involving the educative "framework for action" or learning philosophy called "Constructionism" (Harel and Papert, 1991; Barab & Squire, 2004). Constructionism draws upon both Piaget's constructivist theory and Vygotsky's social constructionist theory, addressing learning as a constructive, social enterprise. Research scholars exploring digital literacy development and learning through project-based content creation and digital work such as game making have observed and measured a range of positive learning outcomes to learner participation in game-making activity when it involves collaborative workshop-based computer programming and design across time (e.g., Harel & Papert, 1991; Harel, 1988, 1989, 1991, 2002; Kafai, 1995, 2006; Wilensky, 2003; Klopfer, 2008; Seely Brown 2005, 2006). For instance, Harel & Papert (1991) found that late elementary school aged students who engaged in a year-long game making project using the programming language Logo experienced positive outcomes in several students, such as meaning-making, appropriation of, commitment to, and sustained engagement in the project, computational and systems-oriented thinking, development of a deeper understanding about the subject of the game (fractions), and a range of affective and motivational changes related to self regulation and self efficacy (Harel & Papert, 1991).

The non-profit founders of the learning innovation investigated in this study have applied Constructionism, situated learning, social learning systems, and computational thinking principles to the program's design and development (Harel & Papert, 1991; Seely Brown, 2005, 2006; Lave & Wenger, 1991; Guzdial & Soloway 2003; Rich, Perry, & Guzdial 2004; Forte & Guzdial 2005). The game design workshop program is a 5-year grant-supported pilot initiative in which a non-profit organization offers school partner participants with a range of affordances and learning supports. In Pilot Year 3 (2009/2010 school year), partner schools implemented the curriculum as an in-school game design course elective offered to students daily for credit and a grade during the regular school day. Students and teachers were provided Flash software licenses for enrolled Game Design students; an open source game design course syllabus and curriculum; a wiki-based e-learning environment containing the syllabus and formatted wiki tools for students' online collaboration, code sharing and game publishing; a suite of targeted free game design tutorials and resources; ongoing in-person student and educator trainings and virtual real-time supports such as virtual office hours with a Flash game design expert. Each syllabus topic is presented as a link on each school's network wiki, providing access into a set of activities, tutorials, and other learning supports, all posted online. Full year students typically proceed through Game Design syllabus topics in Semester One, and Game Development syllabus topics in Semester Two, uploading their files and posting their assignments on their class wiki profile and projects pages. Teachers develop a schedule and assign deadlines for all of these assignments, based on the local needs and timeframe.

The program holds six main dimensions of student practice and expertise as learning objectives (Reynolds & Harel, 2009) presented in the following table.

Table 1. Six Contemporary Learning Abilities Framework

1. **Invention of an original digital project concept** (in this case, a game), **and, successful development and completion of a finished computational artifact representing the concept.**
2. **Project-based learning and project management in wiki-based, networked environment**
3. **Posting, publishing and distributing digital media** (*e.g., creating and uploading digital graphics, interactive designs, videos, notes, prototypes, and games*)
4. **Social-based learning, participation, and exchange** (*e.g., forming and sharing ideas, process notes, programming code*)
5. **Information-based learning, research, purposeful search, and exploration** (*e.g., researching the subject domain of a game; exploring design resources*)
6. **Surfing websites and web applications** (*e.g., game examples, wikis, blogs, web apps*)

The Six CLAs serve as the learning objectives, outcome goals, and drivers for the continued program design and curriculum decisions made in iteratively developing the program. Approaches to teaching digital literacy in the school context have focused on the importance of imparting specific technology *skills*, and have been driven by association standards, for instance the NETS technology literacy standards promoted by the International Society for Technology in Education (ISTE, 2007), and the InfoPower information literacy standards promoted by the American Association of School Librarians and American Library Association (AASL, 2008).

However, while earlier versions of the technology and information literacy standards tended to focus on more "Web 1.0" forms of information-seeking activity, including searching, locating, evaluating and using informational resources online, the most recent updates to both sets of standards incorporate creative technology uses, and dispositions for productivity with technology tools.

For instance, the ISTE NETS standards for students include learning objectives categories such as Standard 1, "Creativity and Innovation," which calls for students to be able to "demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology" (ISTE NETS Standards for Students, 2007). The AASL standards exhort students to gain not just technology skills, but dispositions to use those skills, and AASL Standard 4 is entirely focused on students' pursuit of technology and information uses for personal and aesthetic growth. These standards offer considerable synergy with the Constructionist approaches we have adopted in Globaloria, and achieving these objectives could be seen to *require* Constructionist interventions. Further, the importance of involving learners in programs of creative, project-based digital work is gaining more and more credence as digital literacy, participatory culture and digital divide concerns enter the national educational agenda (e.g., Jenkins, 2009; Hobbs, 2010; Knight Commission on Information Needs of Communities in a Democracy, 2009; Mossberger, Tolbert & McNeal, 2007; National Education Technology Plan, 2010). Unfortunately, while the updated standards and national priorities for instance those mapped out in the National Education Technology Plan of 2010 reflect significant advances in policy guidelines addressing technology integration for learning in schools, the reality is that actual implementation of substantive technology-based interventions in public schools nation-wide is still relatively rare.

In order to support the Globaloria program objectives, the program incorporates a mix of both closely guided instruction and discovery-based learning strategies in its co-learning model, in which students and their educators work together using the syllabus and design resources provided. This means that students have occasion to engage in self-directed inquiry online to seek out learning supports, especially in cases in which their educator is unable to support them in a given task, due to the educator's lack of experience and his or her own ongoing learning curve.

While a range of resources are provided in the online syllabus, including links to specific video-based and written tutorials, the use of such resources appears to require a measure of reflection and self-initiative by student participants as they experience an immediate need in the game design process, and engage in inquiry to seek out resources that meet the need. The rationale for the co-learning model is the larger societal context of technological advancement in which we are educating today's youth and training educators, and the immediate need to train teachers and students on effective technology uses, to bring about a computationally-literate public now, to stem digital divide gaps at both level 1 (access) and level 2 (sophistication of use).

Researchers have observed through participant observation and found support in analysis of open-ended survey response results relating to this program implementation, that some students find discovery-based learning in the program as particularly engaging, whereas others find it somewhat frustrating (Reynolds & Harel Caperton, forthcoming). Kirschner, Sweller & Clark (2006) criticize "discovery-based learning" models as ineffectual, due to the frustration that can result from cognitive load, especially among novice learners who must seek out learning supports to meet design needs in the moment. In contrast, in self-determination theory, scholars including Deci & Ryan (2008) have discovered that three primary constructs underlie intrinsically motivated human behavior, and are innate needs: the need for competence (to be effective), for autonomy (to have choice and control over one's life), and for social relatedness (to feel connected to others, loved, and cared for) (Deci & Ryan, 2008; Deci & Ryan, 2000; Deci & Ryan, 1985). These attributes reside in the individual and can be supported by the environment; individuals will generally pursue goals that allow for these needs to be met, and when these needs are satisfied, they contribute to intrinsically motivated action and psychological well-being (Deci & Ryan, 2000).

The role of autonomy in self-determined behavior in particular appears to conflict with Kirschner, Sweller & Clark's critique, to the extent that discovery-based learning interventions are autonomy-supportive. SDT identifies two types of behavioral regulation in terms of the degree to which they represent autonomous or self-determined (versus controlled) functioning in individuals. Intrinsic motivation is the prototype of autonomous activity; when people are intrinsically motivated, they are by definition self-determined. Extrinsically motivated activity, in contrast, is often more controlled (i.e., less autonomous). Ryan and Connell (1989) have developed a set of validated self-regulation questionnaires that assess domain-specific individual differences in the types of motivation or regulation in the individual, involving the dimensions external, introjected, identified, and intrinsic regulation, which they identified based on past research on perceived locus of control (PLOC) supported cognitive testing with elementary and middle school children, and testing and validation of a range of instruments. Deci & Ryan, the authors of the Self Determination Theory website (http://www.psych.rochester.edu/SDT) state in their online introduction to the validated measures offered on their website that the "regulatory styles, while considered individual differences, are not 'trait' concepts, for they are not general nor are they particularly stable. But neither are they 'state' concepts, for they are more stable than typical states which fluctuate easily as a function of time and place."

In this discovery-based program of game design learning, we expect that the environment is rather autonomy supportive in that students engage somewhat independently in game design as their educators learn alongside them. Thus, we propose the following hypothesis.

H1. The more intrinsically motivated are student digital literacy learners, the better they will perform in meeting the program objectives.

At the same time, the program does offer supports for students such as peer feedback, access to expert advice via online conferencing and Skype office hours, as well as trainings and educator guidance. Further, students are given a grade for their participation, which serves as an external motivator. Therefore, we expect that even those students who are more controlled in their self-regulation style will also succeed and perform well in the program. Therefore, we propose the following hypothesis.

H2. The more student digital literacy learners are extrinsically oriented in their self-regulation style, the better they will perform in meeting their program objectives.

We draw upon Ryan and Connell's (1989) operationalization of the individual difference variables of autonomous and controlled regulation, using their validated questionnaires with students in the game design project.

Investigating the ways that individuals' locus of control contributes to their performance in this context of a discovery-based program of digital literacy learning may elicit findings that are generalizable to the ways that general populations come to acquire digital knowledge and practices, as well.

Method

This paper draws upon several data sources that have been combined into a dataset of all student participants in the Pilot Year 3 research.

Participants

The total number of participants in Pilot Year 3 was 534, with 334 males and 190 females participating. Participation in the research was voluntary, and we acquired signed parent/guardian university IRB-standard permission forms for all 534 students who participated in the program which is managed and operated by the non-profit organization. Copies of the completed consents reside both with the non-profit organization and with the participating schools. Additionally, we have achieved child assents for all student program participants who are minors.

As for the survey response rate, out of 534 student participants, a total of 472 volunteered to complete the pre-survey, and 343 completed the post-survey. The administration protocol for the survey required teachers to inform students in person that their participation was voluntary. As another measure of protection, each online survey session began with a written reminder that participation was voluntary. Skipping questions was permitted. Students were made aware that their responses to the survey would remain anonymous. We placed no time limits on the students; the time needed to complete each of the surveys ranged from fifteen to thirty minutes. The dropoff from pre-survey to post-survey is due to a range of factors, including student voluntary opt-out, student absences at the end of the school year, and student discontinuations in the program, changing of schools, etc.

Table 2. N of students by grade level

	N	Percent
Middle School	64	12.0%
High School	322	60.2%

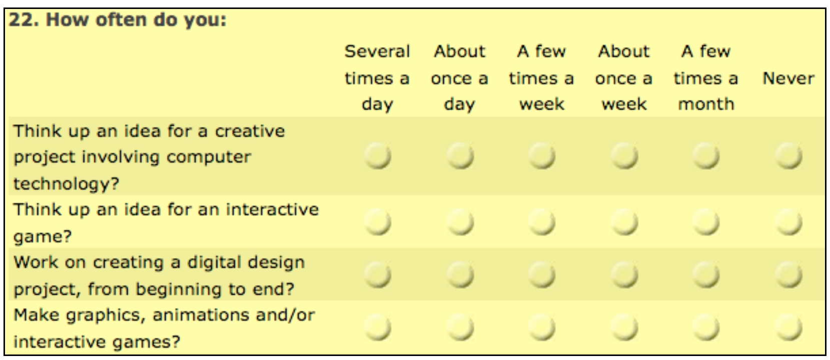
Community College	71	13.3%
Alternative Education	77	14.6%
Total	534	100.0%

Independent variables.

Prior student frequency of engagement in 6 Contemporary Learning Ability practice areas. To begin to validate our theoretical categorization of the 6-CLAs, prior to combining CLA constructs in the survey dataset using multiple survey items, we applied factor analysis to the pre-program survey items representing each CLA category, within the full West Virginia pre-survey dataset (N=472). We hypothesized that the groupings of survey items presented to students reflecting the activities designed to cultivate the CLAs would hang together in factor analysis, reflecting a single factor for each category. We performed factor analysis for each CLA using multiple items provided. It is standard practice in factor analysis to only retain factors with eigenvalues greater than 1. Values greater than 1 indicate that the factor explains a significant amount of the variability in the construct.

Factor analysis confirmed the relatedness of the individual items used to identify each of the CLA factors, with items below hanging together for CLAs 1, 3, 4, 5 and 6 (with eigenvalues >1). See Appendix 2 for the list of items in each factor. For CLA 2, across the dimensions of self-reported frequency, motivation and knowledge, the factor analysis results indicated 2 sub-factors (*creating with digital media* and *collaborating with team members online* separately). Therefore we defined CLA 2 as 2 separate sub-categories. After confirming the constructs' cohesion within the entire pre-survey dataset of WV students, we performed additive combinations for the set of items in each CLA category identified (five single factors, and one factor separated into two sub-factors) for frequency, enjoyment and understanding. We combined appropriate variables in this way in the pre-survey dataset, and in the aligning post-survey dataset. Survey items that did not factor into categories were excluded from the final combinations. Pre/post program survey t-tests were then run, using the single combined construct in the pre- and post- surveys, in each of the 6 CLA categories. In this paper, we report the pre-program survey results across CLAs for frequency of engagement, as evidence for students' relatively low level of engagement, prior to participating. We present pre/post results in separate study.

To measure frequency we used criteria employed by the Pew Internet and American Life Project[1] in their national surveys of media and technology use. An example of the frequency survey items is provided as follows.



22. How often do you:

	Several times a day	About once a day	A few times a week	About once a week	A few times a month	Never
Think up an idea for a creative project involving computer technology?						
Think up an idea for an interactive game?						
Work on creating a digital design project, from beginning to end?						
Make graphics, animations and/or interactive games?						

Figure 2. Survey question on students' frequency of engagement in Six CLAs (screenshot)

Parent Education. For parent education, we asked students in the pre-survey to identify the level of education for each parent separately. We expect parent education to serve as a proxy for socio-economic status. The scale for parent education that was used was 1= Did not complete HS; 2= Completed HS; 3= Completed HS, attended some college; 4= Completed college (at least 4 years); 5= Completed college, attended some graduate school; 6= Completed graduate school.

Among the two survey questions (parent 1, parent 2), the parent education value we used in our analysis was the level of education for the one parent with the highest education level, since many students only responded for one parent.[2]

[1] See www.pewinternet.org

N of participation months. Here we used the educator progress reports that itemize each students' progress at each pilot location at four points across the year-long timeframe (two fall, two spring). At some locations, students only participated for a single semester. Thus, N of participation months was an important variable to consider when investigating student performance. We calculated this at the level of number of months.

Self-reported grades. Here we asked students the question in the pre-survey, "What grades do you usually receive on your report card?" We provided the following categories, measured and reverse-coded on a 5-point scale (all A's (or 4's); mostly A's and some B's (or 4's); mostly B's and some C's (or 3's); mostly C's and some D's (or 2's); mostly D's and F's (or 1's).

Motivation questionnaires. Here we draw upon Ryan and Connell's (1989) validated questionnaires. These authors found good discriminant validity in their measure for two main self-regulation dimensions (intrinsic, versus extrinsic). That is, factor analysis of items in each of the four dimensions related meaningfully to the external criteria, wherein two factors emerged, with expected items on the extrinsic side of the four-category continuum falling into a factor the authors label "controlled regulation" (external, introjected) and the other expected items falling into another factor the authors label "autonomous regulation" (identified, intrinsic) (1989). Each questionnaire asks why the respondent does a behavior (or class of behaviors) and then provides several possible reasons that have been preselected to represent the different styles of regulation or motivation. The first two questionnaires were developed for late-elementary and middle school children, and concern school work (SRQ-Academic). The adaptation we used here draws

[2] The relationship between adolescents' self reports and parents' actual reports of parental education has been found in a previous study to be in fair agreement; kappa statistics were 0.30 and 0.38 for fathers' and mothers' education, respectively (Lien, Friestad, Klepp 2001). This finding supports the validity of using student self-reports of parent education.

upon more recent refinements in the measure (Black & Deci, 2000; Williams & Deci, 1996). The instrument is provided in Appendix A, with the scoring method.

Student Wiki and Blog Activity. Students engage in wiki editing for the following purposes: to create their online identity on their Profile pages; to complete assignments on their Projects pages; to embed uploaded files to their Projects pages using wiki code; to edit and embed uploaded files to their team project pages; to communicate with each other on Talk pages and other pages, providing feedback on project assets, and to add playful social commentary. Wiki activity indicates the extent of student engagement in the collaborative, project management, and publishing dimensions of the CLAs, 2, 3 and 4. Because the MediaWiki tools used provide an archive of history, we could hand-count student wiki activity using a summary activity page provided for each member ID in the tools. The N of Wiki edits tell us how many times students edit and save pages. File uploads data were also counted at the individual level for each and every student participant indicating how many project file uploads were made by students as an indicator of their productivity in game design. The upload data indicates their level of engagement in CLA 1, that is their use of Flash software to create an original, digital project file (that is, a Flash game using Actionscript code). We distinguished between SWF/FLA files and other file types.

Blog Posts. Students in the game design program write blog posts to reflect on their process, write reviews of games they test, discuss their process, address topic prompts posed by their educators, and engage in free writing. We also tallied all blog activity across the school year for all students, counting total N of posts (in Pilot Year 3, we did not count word length for each post, or, quality/substance of the reflection).

Dependent variable

Game quality. Here we engaged in content analysis of all student final games, and then added the final outcomes at the individual level to our pre/post survey dataset as a combined, additive value. Neuendorf defines content analysis "as the systematic, objective, quantitative analysis of message characteristics" (2002, p.1). She explains that in order to use content analysis, the text must consist of "communication content as a primary subject of the investigation" (p. 14) and she notes that "the text of a film includes its dialog, its visuals, production techniques, music, characterizations, and anything else of meaning presented in the film" (p. 15). In the case of web games, the text is the social or educational message students build into them (such as global warming, or social / cultural themes local to West Virginia). Also, the game files demonstrate student production techniques. That is, the medium itself (the game design and mechanics of the game evidenced in the SWF and FLA files) is part of the message we evaluate.

Therefore, we evaluate functionality built into students' completed games (mechanics), as well as the game's cultural content and design. Game artifact content indicates student engagement in the program, and signals CLA development of the more Constructionist CLAs 1 and 2 (while also partially indicating CLAs 3, 4 and 5). The purpose for evaluating games is to better understand the range of game mechanics and messages students achieved in their particular school setting, identify patterns, and explore explanations. We also evaluate games to better understand the extent of knowledge students are gaining.

Coding Scheme Development. The six CLA objectives (especially the first three), and the literature that influenced them guided our work in coding scheme development. Rourke and Anderson (2004) provide five steps to developing a theoretically valid scheme. The first is to identify the purpose of the coding data; the second step is to identify behaviors that represent those constructs. They suggest that a literature review can help to identify representative behaviors. The second step involves studying the data in open coding. We reviewed student games and wiki interactions to refine the scheme; especially the codes addressing game genres and concept development. The third step (2004) consists of reviewing the categories and indicators of the scheme, enlisting experts. Scholarly works by experts who use content analysis to study games largely focused on commercial games with the intention of understanding gender roles and levels of violence in *gameplay* (for example, Beasley and Standley 2002; Dietz 1998; Ivory 2006; Thompson and Haninger 2001). Walker and Shelton (2008) created a rubric for assessing problem-based learning outcomes and characteristics in video game play. Rice (2007) constructed an evaluative rubric to assess the amount of higher-order thinking required in video game *play*.

We applied Walker & Shelton's (2008) general coding strategy of measuring presence or absence of the variables (1=Yes, 0=No) for our evaluation of Actionscript inclusion in games. We also observed that these authors (2008) and Rice (2007) had codes that were more parsimonious than those used in a previous coding scheme draft the year before, prompting further refinement. Through review of this literature we also realized the need to explicitly define what constituted a web game in the program context. We define "game" as: a file that goes beyond a mere image, to include some level of interactivity, in which, at minimum, the file provides response to the player, based on a player action. The format of the game files students post online include both .SWF (Small Web Format / Shockwave Flash) and the .FLA project file format. To be evaluated files must reflect at least an actionable button and response screen, or an object that moves based on player actions. Distinguishing and defining a "game" at this most minimal level of interactivity allows us to code the full range of game files created by students, basic to advanced.

We also consulted with an industry expert on Flash game and simulation design. Her consulting process involved review of the online syllabus to identify main areas of focus in the game design curriculum; review of the SWF and FLA files for 5 games, and thinking about the range of student abilities reflected in the games; developing an initial set of Actionscript elements that were commonly used by developers and reasonable to be expected in a student game; and revising the previous version used in the year before, to evaluate SWF files, refining language and revising main header categories.

The result was a new draft of the coding scheme improving upon that used in the year before. Practice coding is the fourth step (Rourke and Anderson, 2004), and this was conducted by four coders (three experienced Flash designers, and one lead researcher), who all analyzed a set of five common games. The group reviewed discrepancies, and further revised the coding scheme, removing redundant categories, refining language, and establishing a 3-point scale for the design evaluation instead of 0/1. The final coding scheme allows evaluation of Actionscript programming codes that could reasonably be expected from introductory game design students (1=present, 0=absent), and, evaluation of design attributes built into the game (visual and sound design elements, game play experience, concept development, genre) (1=Not present / insufficient representation; 2=basic / introductory representation; 3=well-developed representation). The highest possible score was 61. The lowest possible score was 16.

The final coding scheme is presented in Appendix C. Inter-coder reliability was conducted on 29 student games created in Pilot Year 3 (out of 216 games in total). To establish reliability, after our initial testing phase of the coding scheme, we trained a PhD student coder, discussing and establishing best process for analyzing Flash code to ensure that code on both frame layers and movie clip objects were taken into consideration. The 29 games were then coded by two people: a) the author and b) a PhD student. Inter-rater reliability analysis using the Kappa statistic was conducted to determine consistency among raters. We performed the analysis for each section of the coding scheme. Results are presented separately for each section below.

Actionscript programming evaluation. The inter-rater reliability was found to be Kappa = 0.85 (p <.0.001), 95% CI (0.793, 0.903).

Visual and sound design evaluation. The inter-rater reliability was found to be Kappa = 0.81 (p <.0.001), 95% CI (0.725, 0.894).

Game play experience evaluation. The inter-rater reliability was found to be Kappa = 0.87 (p <.0.001), 95% CI (0.775, 0.955).

Concept development evaluation. The inter-rater reliability was found to be Kappa = 0.75 (p <.0.001), 95% CI (0.658, 0.846).

Genre. We achieved full agreement in all 29 cases for the Genre code. For the Subject code, this category was open and will be reported as inductive results. All of these results present acceptable levels of inter-rater reliability for the coding scheme, indicating that using the scheme, independent coders have evaluated these 4 different characteristics of the game artifacts, and reached the same conclusions.

Student work in Pilot Year 3 yielded 216 games. The table below reports the game genres, analyzed by a trained PhD student coder. Games that were coded as core curriculum topics include themes on traditional school subjects (English, math, science, social studies). Games that were purely entertainment and did not contain any substantive content theme were coded as Entertainment. We also have an Other category, which include games that bear for instance engineering, technology, social issues themes that were not science, and other substantive themes that do not fit the criteria above. We were also interested in games that could be characterized as STEM, due to our interest in the future in evaluating the extent to which game design can support STEM content learning. Thus, we calculated an additive value for the N of STEM games. The same was the case for some locations that focused on developing Civics games. Thus, we counted games in the Civics genre as well. Further, we tallied all of the games whose subjects had a global social issue theme such as climate change, pollution, poverty, etc., which commonly overlapped with Science, or Other categories. All of these games in the aggregate categories were also counted in one of the singular categories outlined above.

Table 3. Year 3 final games created

Total Game Projects Created	216
Student Games by Focus	
Math	26 (12%)
Science	79 (37%)
English	1 (0%)
Social Studies	46 (21%)
Entertainment	28 (13%)
Other (e.g., engineering, technology, manufacturing, education, poverty, etc.)	36 (17%)
Student Games with a Social Justice Issue Theme (e.g., the environment, poverty, nutrition, health care) – many are also science games, or, "other" games; all are also counted above	
Social Issue Game	72 (33%)
Student Games Focusing on STEM or Civics (all are also counted above)	
STEM Games	114 (53%)
Civics Games	36 (17%)
Individual vs Team Games	
Total Games made by an Individual	59 (27%)
Total Games made by a Team	157 (73%)

Out of the total set of student participants (N=534), 415 students either participated in teams that created games, or created games individually. A total of 119 students did not get far enough in their game design learning to achieve development of a game that fit our definition (file containing interactivity) that could be coded and analyzed, and thus were coded as missing data. This is a limitation; next year we will revise our coding scheme so that such in-progress but incomplete projects are reflected in the coding scheme outcomes. In all of our survey results and data analysis, students at two alternative education schools are also omitted, because students at these locations did not advance far enough in their learning to create games for evaluation, they did not participate daily, and the program was not offered for a grade, thus the program attributes for these two locations were inconsistent with the other locations.

Results

Descriptive results

Table 4. provides the descriptive data (mean, minimum, maximum, standard deviation) for the variables used in this study among the remaining 20 middle schools, high schools, and community colleges.

Table 4. Descriptive Statistics of Variables Used in the Analyses

	N	Minimum	Maximum	Mean	Std. Deviation
Post-Intrinsic Orientation	321	1.00	5.00	3.90	.86
Post-Extrinsic Orientation	320	1.00	5.00	2.91	.73
N Wiki edits	448	0	1239	114.27	133.94
FLA uploads	448	0	74	10.27	14.15
SWF uploads	448	0	77	14.32	14.99
Other uploads	448	0	243	13.38	21.14
Blog posts	412	0	80	25.16	17.21
N Participation Months	447	4	9	6.61	2.53

Game quality	415	16.00	52.00	26.84	8.28
Self-reported grades	423	1.00	5.00	3.72	.80
Parent Education	397	1.00	6.00	3.24	1.26
Valid N (listwise)	244				

Prior technology engagement. We present descriptive data on prior technology engagement to affirm the novice status of participations prior to their participation. We segment our prior technology use data into middle school, high school, and community college categories. The valid N (listwise) for middle school student respondents for the pre-survey frequency questions was 56; the valid N (listwise) of high school respondents for the pre-survey frequency questions was 208. The valid N (listwise) of community college students for the pre-survey frequency questions was 41. We omit the two alternative education locations. See Appendix B for the survey items used in creation of the CLA construct categories.

Results indicate that prior to Globaloria, on average, for CLAs 1-3, middle school and high school students participated in the range of practices we measured with a mean frequency of less than once a week. For the less-Constructionis CLAs 4-6, it appears that high school students participated somewhat more frequently. For the range of practices, it appears that the community college students who are older present somewhat higher frequency means for prior technology use, except for the category of collaborating with team members.

Table 5. Middle, high school, and community college students' pre-program frequency of engagement in practices in the 6 CLA categories

CLA #	CLA Name	MS Pre-Survey Mean	Std Dev.	HS Pre-Survey Mean	Std Dev.	CC Pre-Survey Mean	Std Dev.
CLA 1:	Inventing creative project ideas	2.20	1.29	2.77	1.71	3.17	1.78
CLA 2:	Project-based learning and project management						

2a:	*Creating digital media with software*	1.73	0.83	1.88	1.10	2.46	1.44
2b:	*Collaborating with team members*	1.46	0.80	1.46	1.01	1.76	1.34
CLA 3:	Publishing/distributing digital media	1.94	1.12	2.06	1.36	2.63	1.35
CLA 4:	Learning with social media	2.20	1.38	2.75	1.61	3.87	1.50
CLA 5:	Information-based learning, research, purposeful search	2.65	1.00	3.51	1.32	4.50	0.99
CLA 6:	Surfing websites and web applications	2.77	1.70	3.71	1.70	4.60	1.48

Source: Globaloria West Virginia Pre-and Post-Program Survey, STUDENTS, Pilot Year-3. Two alternative education schools are omitted.

Survey item scale (*How Often Do You ...*): 1 = Never , 2 = A few times a month, 3 = About once a week, 4 = A few times a week, 5 = About once a day, and 6 = Several times a day. The valid N (listwise) for middle school student respondents was 56; the valid N (listwise) of high school respondents was 208. The valid N (listwise) of community college students was 41.

Data Analysis. Ordinary least squares (OLS) regression was used to analyze the hypotheses. The correlations between these independent variables were not so high as to suggest covariance. Table 6 indicates the Pearson correlation coefficients for all variables.

Table 6. Pearson Correlation Coefficients for Variables Used in the Analysis

	1	2	3	4	5	6	7	8
1. N Participation Months								
2. Parent Education, R	-0.031							
N	397							
3. Self-reported grades, R	0.071	.22**						
N	422	385						
4. N Wiki edits, R	0.016	-.12*	.14**					
N	446	397	423					
5. FLA uploads, R	.11*	-.18**	.18**	.40**				
N	0.018	0	0	0				
6. SWF uploads, R	.19**	-.11*	.25**	.40**	.80**			
N	446	397	423	448	448			
7. Other uploads, R	0.063	-.13**	0.018	.33**	.30**	.27**		
N	446	397	423	448	448	448		
8. Blog posts, R	.52**	0.071	.13**	0.074	0.076	.31**	0.012	
N	410	365	389	412	412	412	412	
9. Intrinsic orientation, R	0.047	-0.028	.13*	0.008	.17**	.19**	0.051	0.082

N	319	277	306	321	321	321	321	304
10. Extrinsic orientation, R	0.014	0.002	0.056	0.014	.12*	0.11	0.10	-0.056
N	318	277	306	320	320	320	320	303
11. Game evaluation, R	-0.071	-0.02	.20**	.27**	.45**	.42**	0.021	-0.033
N	412	367	392	414	414	414	414	382

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

Hypotheses 1 & 2. To test hypotheses 1 & 2 we measured the effect of the intrinsic and extrinsic motivational orientation upon students' game evaluation quality outcomes, over and above two previous sets of variables (in Model 1, demographic variables N of participation months, parent education, and self-reported grades; in Model 2, wiki/blog activity as measured by wiki edits, FLA uploads, SWF uploads, other uploads, and blog posts). We first measured the initial two Models, and then measured the contribution of the main independent variables over and above the other explanatory variables. Results are presented in Table 7.

Table 7. Ordinary Least Squares Regression Predicting Game Evaluation Quality

	Project Participants		
	Model 1	Model 2	Model 3
Variable List	Standardized Beta	Standardized Beta	Standardized Beta
N Participation Months	-0.036	-.10	-.10
Parent Education	-0.12	.02	.02
Self-reported grades	0.17**	.03	.02
N Wiki edits		0.07	.09
N FLA uploads		0.15	.15
N SWF uploads		0.39***	.38***
N Other uploads		-0.19**	-.19**
N Blog posts		-0.09	-.11
Intrinsic orientation			.16*
Extrinsic orientation			-.13*
Intercept	23.71	25.10	23.84
n	240	235	233
R^2	.035	.27	.29
Adjusted R^2	.023	.25	.26

Results for Model 1 indicate the contribution of the demographic variables of N of participation months, parent education and self-reported grades on their own, to student game quality. For Model 1, the R^2 results are statistically significant, $F(3, 240) = 2.9$, $p<.05$ with these variables accounting for a slight 2.3% of the variance in game quality.

Results for Model 2 indicate the additional contribution of the wiki activity and blog variables to student game quality – over and above the demographic variables. For Model 2, the R^2 change is .24 over and above Model 1, and results are statistically significant, $F(5, 235) = 11.02$, $p<.001$, accounting for 25% of the variance in game quality.

Results for Model 3 indicate the additional contribution of the intrinsic and extrinsic motivational orientation variables to student game quality – over and above the demographic and wiki/blog activity variables measured in Models 1 and 2. For Model 3, the R^2 change is a slight .02 over and above Model 2, however, results for the R^2 change are statistically significant, $F(2, 233) = 9.61$, $p<.05$, accounting for a total of 26% of the variance in game quality.

Overall, results support the first hypothesis posed by this study:

H1. The more intrinsically motivated are student digital literacy learners, the better they will perform in meeting the program objectives.

Results indicate that an autonomous regulation orientation contributes positively to higher quality of student game designs as an outcome, even when accounting for demographic variables such as self-reported grades (school achievement) and level of effort extended in publishing files to the wiki (SWF uploads). Interestingly, it also appears that when students post other types of files to the wiki such as JPGs or other images, this is negatively contributory to student game quality. Participant observational research indicates that students who predominantly posted static image files appeared less likely to have developed Flash and Actionscript skills.

Hypothesis 2 is restated as follows: “The more student digital literacy learners are extrinsically motivated, the better they will perform in meeting their program objectives.” For Hypothesis 2, the results are unsupported. In fact, the study reveals a negative statistically significant contribution of extrinsic motivational orientation upon game quality. This finding is interesting, and indicates that while the discovery-based co-learning environment in which this program is conducted appears conducive to autonomous, intrinsically motivated learners, it may forestall those with a “controlled” self-regulation orientation; that is, those who are more extrinsically motivated. We see in the Pearson correlation coefficients that intrinsic motivational orientation is positively correlated to self-reported grades whereas extrinsic motivational orientation with school achievement is non-significant. However, using OLS regression we see that even when accounting for the self-reported grades variable in the first regression model, both regulation types are statistically significant (positive, and negative) contributors to game quality.

Discussion

It appears that discovery-based programs of learning such as the Globaloria program implemented in West Virginia schools may be supportive of the autonomous natures of those with an intrinsic motivational orientation. However, students with an extrinsic regulation structure may become frustrated and have a less positive experience and extent of learning. The proposed causal linkage for the negative result may be the discovery-based nature of the project, as discussed in previous program findings of Reynolds & Harel Caperton (2011), and the work of Kirschner, Sweller & Clark (2006), who criticize discovery-based learning programs outright as ineffectual for novice learners due to heavy cognitive load. However, the positive results may indicate that the research on self-determination theory and intrinsic motivation (e.g. Deci & Ryan

2000) has light to shed on this picture; for those with intrinsic motivational orientations, perceived autonomy and actual opportunity for autonomous engagement offered in an educational intervention may counterbalance the cognitive load effect. Persistence and effort appear to be maintained in this project by intrinsically motivated students (whether or not they were experiencing cognitive load), as indicated by the positive relationship to game quality outcomes.

Reynolds & Harel (2011) discuss contrasting findings among student affect towards self-driven learning activities in Globaloria. Student open-ended content analyzed responses to a mid-survey indicate feelings of frustration among some as it relates to such activities, and in contrast, enjoyment among others (2011). Further research is needed to understand whether intrinsically motivated students who persevere in the face of challenging self-driven “ill-structured” work scenarios do so with negative affect, in spite of their frustrations (indicating that intrinsic motivation and perseverance may just be counter-balancing the frustration), or, whether intrinsically motivated students who persevere in the face of challenging autonomous tasks do so *with enjoyment due to the autonomy* (indicating that the negative frustration and motivational hindrance that Kirschner, Sweller and Clark [2006] associate with cognitive load is in fact in need of qualification, for those who are intrinsically motivated).

One area of vagueness in the present study is the extent of self-driven activity students encounter in Globaloria. More research is needed to narrow in on implementation variables inherent to discovery-based learning model and intervention that our study does not precisely measure, such as a) variance in self-driven learning tasks at different schools; b) specific time on task at finer measurement level than participation months; and c) sequence of learning activities and varying implementation contexts by school. For instance, there may be moderating effects inherent to variations in the program implementation at different locations, such as educator attitudes, expertise, etc., that further refine the construct "discovery-based learning" we are using to characterize the intervention implemented. Further, we need to understand how student frustration, negative affect, and/or enjoyment mediate or moderate the relationships we are exploring.

As the results stand, the context in which students learned in Pilot Year 3 holds similarities to the naturalistic digital environments in which all of us find ourselves challenged to engage with and learn to use effectually. Therefore, these findings may have implications for the engagement of the general population in digital online activation and participation, for instance for cultural and political capital purposes. In particular, it may be that we can expect those with a more autonomous self-regulation disposition to be more likely to actively engage in online participatory activity (unless some kind of extrinsic reward is provided, and sustained). It may be such autonomously oriented individuals who have the motivation to seek out creative and participatory content development opportunities online, using the resources and affordances that have so recently become available.

Further, in the context of digital literacy interventions among disadvantaged groups who are newly introduced to such affordances, it may be the autonomously oriented individuals among such populations who leverage these opportunities and take most advantage of them.

This initial study has other limitations that require noting. One limitation of this research is the drop off rate in the post-survey, from which the autonomous and controlled regulation variables were derived. Some of the drop off is unexplained, given that the research was conducted remotely via online surveys and retrospective content analysis. Budgetary constraints hindered researchers from being present in each classroom to monitor and observe the educators' administration of the surveys, and conduct of the program. However, that stated, the wiki and extensive multitude of student artifacts provided online served as a valuable data source for the dependent variable of student learning. Frequent interactions between researchers and program staff also helped. Another limitation is the necessity to omit two schools.

Further, in our study we evaluated students' *team* games as our knowledge construct. In most cases, students worked in teams of 2, 3, or 4. Thus, in the creation of our dataset, we spread the grouped team-level evaluation values to each unique team member of a given small group in our individual student dataset case rows. We were fortunate to have mapped which team member was in what team, at each location, through the teams' pages on the wiki, very specifically. The individual game evaluation value for each small group member thus reflects the outcome of the small teams' collective group cognition. Thus, the individual game evaluation values reflect the *maximum* amount of learning for an individual in each team as evidenced by their team final games.

This research program if continued offers practical contributions to the implementation and improvement of the digital literacy learning program implemented. By further exploring and applying these results, we can achieve greater consistency across the locations, and improve supports for individual learners – especially those who may have a more controlled regulation structure. Given the outcomes we have measured, the autonomous versus controlled motivational orientation instrument could be used up front to diagnose and identify such students' dispositions, so that the teachers can be sure to offer controlled orientation individuals extra support in the discovery-based learning model, and/or provide them with improved access to the learning supports afforded by the non-profit organization, beyond the local capacity.

As of this publication, Globaloria is already in Pilot Year 4 (2010/2011), with a growing dataset of 1000 students as the program scales. The present study has led us to new research questions and a greater level of focus. We are continuing to explore how the program is becoming instantiated, and how learning and knowledge are created and shared among educators and students in the co-learning model, within and across varying networked locations, across multiple grade levels, and among participants with varying levels of expertise in this "social learning system" (Wenger, 2003). To further substantiate our findings from Pilot Year 3, we will conduct this analysis again in Pilot Year 4, including additional variables for analysis. We expect our work will contribute to the current and ongoing debates in the field of the learning sciences, with regard to discovery-based learning, cognitive load theory, and the role of autonomy in self-determination theory. It also appears that these variables may be relevant to exploration of the general population's acquisition of digital literacy skills and knowledge. Therefore we propose this inter-disciplinary research is relevant to the field of Communications as many of us continue to investigate the problems of the digital divide, in the context of the emergence of participatory digital socio-political issues and cultures.

Appendix A

Self Regulation Survey Items

Scoring occurred by calculating the two subscale scores by averaging the items on that subscale.
Autonomous Regulation: 1, 3, 6, 9, 11, 13, 14
Controlled Regulation: 2, 4, 5, 7, 8, 10, 12
In past studies, the alpha reliabilities for these two subscales have been approximately 0.75 for controlled regulation and 0.80 for autonomous regulation.

Please indicate how true each statement below is, for you.

6. I participate actively in the Game Design class:

	Not at all true	Not usually true	Sometimes true	Usually true	Very true
Because I feel like it's a good way to improve my skills and my understanding of game design and technology.	○	○	○	○	○
Because others would think badly of me if I didn't.	○	○	○	○	○
Because learning to use technology well is an important part of preparing for my future.	○	○	○	○	○
Because I would feel bad about myself if I didn't study this.	○	○	○	○	○

7. I follow along with the class lessons to learn Game Design and Technology:

	Not at all true	Not usually true	Sometimes true	Usually true	Very true
Because I expect to get a good grade if I follow the class lessons.	○	○	○	○	○
Because I believe the class will help me use technology effectively.	○	○	○	○	○
Because I want others to think that I am good with technology.	○	○	○	○	○
Because it's easier to do what I'm told than to think about it.	○	○	○	○	○
Because it's important to me to do well at this.	○	○	○	○	○
Because I would probably feel guilty if I didn't comply with the class lessons.	○	○	○	○	○

8. I plan to continue strengthening my technology and game design skills:

	Not at all true	Not usually true	Sometimes true	Usually true	Very true
Because it's exciting to try new ways to use technology for game design.	○	○	○	○	○
Because I would feel proud if I continued to improve at technology and game design.	○	○	○	○	○
Because it's a challenge to really understand how to design and program games.	○	○	○	○	○
Because it's interesting to use technology to identify how to best design and program games.	○	○	○	○	○

Appendix B

Survey Variable Composites: CLAs

To begin to validate our theoretical categorization of the 6-CLAs, prior to combining constructs we applied factor analysis to the pre-program survey items representing each CLA category, within the full WV dataset (N=472).

Several items were provided for each category (see the tables below for survey items). Exploratory factor analysis results confirmed 8 factors, instead of 6. The factor analysis confirmed CLAs 1, 3, 4, and 5, plus 2 factors for CLA 6 (*surfing* and *gaming* separately), and 2 factors for CLA 2 (*creating with digital media* and *collaborating with team members online* separately). We therefore performed additive combinations for the set of items in each CLA identified (four single factors, and two factors separated into two sub-factors). Survey items that did not factor into categories were excluded from the final combinations.

CLA 6

Survey Items for *FREQUENCY*

CLA 6. Surfing websites and web applications How often do you… 7-point scale: 1=Never, 2=less often but sometimes, 3=a few times a month, 4=about once/week, 5=a few times/week, 6=about once/day, 7=several times/day
Activities
Surf online for fun

CLA 5

Survey Items for *FREQUENCY*

CLA 5. Information-based learning, purposeful search and exploration
Activities (1 Factor)
Use a search engine to find resources when you think of a question about something? Use Wikipedia? Use a search engine to find resources for help with a digital design project?

CLA 4

Survey Items for *FREQUENCY*

CLA 4. Social-based learning, participation and exchange in a networked environment
Activities (1 Factor)
Exchange messages in email? Exchange messages in instant messenger or chat? Use social network sites like Facebook or Myspace?

CLA 3

Survey Items for *FREQUENCY*

CLA 3. Publishing and effective distribution of digital media
Activities (1 Factor)

Post content/messages on a wiki? Post content/messages on a blog? Post graphics/animations/games you've created to the internet? (MyGLife.org, etc.) Post digital video to the internet? (Youtube, etc.)

CLA 2

Survey Items for *FREQUENCY*

CLA 2. Project-based learning and online project management in a wiki-based networked environment
Activities (2 Sub-Factors)
Factor 1: Creating digital media
Make graphics, animations and/or interactive games? Make digital music or video on a computer? Program on a computer? (Actionscript, etc.)
Factor 2: Collaborating with team members
Work with a team on a digital design project, communicating with team members ONLINE? Work with a team on a digital design project, communicating with team members FACE-TO-FACE?

CLA 1

Survey Items for *FREQUENCY*

CLA 1. Invention, progression, and completion of an original digital project idea (for an educational game or simulation)
Activities (1 Factor)
Work on creating a digital design project, from beginning to end? Think up an idea for a creative project involving computer technology? Think up an idea for an interactive game?

Appendix C

Final Coding Scheme

The codes in the final coding scheme are presented as follows.

Table 1. Programming categories (0=not present, 1=present)

roll over/roll out		preloader	if statements* (conditional executions)
Button presses	timer *	load sound	
hit test/collision detection	drag and drop	Physics engine	
key press	dynamic text or input text	variables	
on enter frame *			

Table 2. Design categories (1=Not present/insufficient representation; 2=basic/introductory representation; 3=well-developed representation)

Visual and sound design element
The visual design of the game creatively reflects the concept of the game (e.g., the designer uses color, shapes, and patterns so that the visuals and design reinforce the ideas in the game design plan)
The visual / graphic style carries throughout the game consistently (e.g., elements of color-scheme, character design, game-play objects are held consistent throughout the game)
Sound is used to enhance game-play (e.g., no sound = 1. if certain objects have sound embedded = 2. If sound is used to enhance experience overall =3)
Non-player moving characters and animated objects in the game provide dynamism to the game play (e.g., graphic animation elements are created and included as files)
Sprites, animations and/or sounds add to the coherence of the design plan and game story; they encourage players to immerse themselves in play
Game play experience
Game instructions are clear and helpful to the viewer
Game provides helpful feedback when the player advances or fails to advance through the game (e.g., quiz game provides feedback on a response; when a character dies a life is lost or a message appears, etc.)
Game is navigable and intuitive to use
Game mechanics are simple to understand and learn, but challenging to master
Based on their game design plan on the wiki, it appears that students have a clear idea of their "audience", and their game design has been executed to address this audience based on the plan.
Concept development
The game provides enough context up front (either in the storyline or mechanics) so that the game's objective, strategy are apparent to the player.
Game concept, storyline are coherently integrated with the mechanics and gameplay (e.g., an educational game uses effective instructional strategies; social issue games use mechanics that fit well with expressing the topic, etc.)
Any facts included are presented accurately and reflect research.
Any facts are integrated with the game concept and game mechanics, not as isolated quizzes
Game has an ending/conclusion that provides closure to the player.
The game design document on the wiki is thorough, clear, understandable.
Genre
Is the game a Social Issue game, an Educational game, or an Entertainment game? (write out which)
If the game is educational, what is its topic? Please state if it could be considered science, technology, engineering, math, or civics. If not, what is the topic?

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