LEARNING AND GENDER DIFFERENCES IN A NARRATIVE-CENTERED LEARNING ENVIRONMENT

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Abstract: This study examined the performance of 8th grade students within a narrative-centered learning environment (NLE) focused on science content. Students showed significant increases in science content knowledge after gameplay. Performance in the NLE was related to higher science self-efficacy and also led to increased presence, interest, and transfer of science concepts. No differences were found between genders for content knowledge, however different variables predicted success by gender. In addition, males entered the study with higher levels of reported gaming experience and showed early advantages for game score that dissipated by the end of play. Further findings and implications for learning are discussed.

1 INTRODUCTION

Situating game-based learning exercises within a narrative-centered approach is one strategy for enhancing student learning and engagement. Stories draw audiences into plots and settings, thereby opening perceptual, emotional, and motivational opportunities for learning. Fantasy contexts in educational games have been shown to provide motivational benefits for learning (Parker & Lepper, 1992). Narrative features such as pacing and tension can introduce additional challenge to learning tasks and contribute to student motivation. Establishing concrete connections between narrative context and pedagogical subject matter has also been said to support the assimilation of new ideas in young learners (Wells, 1986).

Narrative learning environments (NLEs) leverage a range of techniques for providing effective, engaging learning experiences. Multi-user virtual environments such as Quest Atlantis (Barab et al., 2007) and River City (Ketelhut et al., 2007) use rich narrative settings to contextualize inquiry-based science learning scenarios with strong social and ethical dimensions. Several empirical studies from this work have yielded promising learning results that support the promise of NLEs in the classroom.

Gender is also a variable of interest within NLE's. Many factors influence gender's effects on student performance, engagement, and interest in game-based learning environments. These include but are not limited to ability, beliefs, virtual gaming preferences, and characteristics of the environment itself. Characteristics that make video games appealing to boys and girls have been noted as consistently different (Cassell & Jenkins, 1998). Girls tend to prefer story development, relationships, and collaboration, whereas boys tend to prefer competition and aggression (Cassell & Jenkins, 1998). Also, recent research has found that girls report higher self-efficacy for science and self-efficacy for self-regulated learning than boys at the middle school level (Britner & Pajares, 2006). Moreover, the gender of characters that student interact with within virtual environments have been shown to affect student attitudes about math and science (Kim & Baylor, 2006). Therefore, the extent to which these elements generalize and impact performance in NLEs is an important line of research.

A number of interesting gender differences have emerged in recent studies using NLEs. For example, males tend to engage in more off-task behaviors (Rowe et al., 2009), females report higher levels of presence (McQuiggan et al., 2008a), and females, when allowed, record greater amounts of notes (McQuiggan et al., 2008b). Further investigation of these effects as well as other factors that influence male and female performance motivation within this context is imperative for the production of NLEs that are effective for both genders.

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1.1 CRYSTAL ISLAND

In our laboratory we have developed an inquiry-based NLE called CRYSTAL ISLAND - OUTBREAK (see Figure 1) in the domain of microbiology for middle school students. CRYSTAL ISLAND - OUTBREAK features a science mystery set on a recently discovered volcanic island where a research station has been established to study the unique flora and fauna. The student plays the protagonist attempting to ultimately discover that the milk on the island is carrying an unidentified infectious disease by utilizing resources at the research station. The story opens by introducing the student to the island and the members of the research team. As members of the research team fall ill, it is the student's task to discover the cause of the specific source of the outbreak. She is free to explore the world and interact with other characters while forming questions, generating hypotheses, collecting data, and testing the hypotheses. Throughout the mystery, the student can walk around the island and visit the infirmary, the lab, the dining hall, and the living quarters of each member of the team. The student can pick up and manipulate objects, talk with characters to gather clues about the source of the disease. Facts and clues revealed during the student's interaction can be stored in a virtual factsheet. Some characters within the game serve as local experts on certain pathogenic diseases. During the student's interactions with such expert characters, in-game quizzes are presented to test the student's knowledge of the character's specific expertise. In the course of the adventure, the student must gather enough evidence to correctly identify that is in fact the milk has been contaminated with E-Coli. To win the game, the student must have submit a correctly filled factsheet with information about the source object, disease, and treatment.

Figure 1: The CRYSTAL ISLAND - OUTBREAK environment.

2 METHOD

An experiment was conducted involving the entire eighth grade population of a North Carolina middle school. The research questions included: 1. *What effect does completing the* CRYSTAL ISLAND - OUTBREAK *mystery have upon learning? 2. How does gender affect gameplay?*

2.1 Participants

A total of 130 eighth grade students ranging in age from 12 to 15 (M = 13.28, SD = 0.48) participated in our study. 73 were male and 57 were female. Approximately 3% of the participants were American Indian or Alaska Native, 2% were Asian, 32% were African American, 13% were Hispanic or Latino, and 50% were European American. The study was conducted prior to students' exposure to the microbiology curriculum unit of the North Carolina state standard course of study in their regular classes.

2.2 Materials

Gaming Demographics Survey. A three-question, researcher-developed gaming demographics survey was completed by the participants prior to interacting with CRYSTAL ISLAND - OUTBREAK. The survey asked students to rate how frequently they play games and their perceived game-playing skill on a 5-point Likert scale. Also, the students were asked to estimate how many hours they spend playing games per week.

Science Learning Self-efficacy. A science learning self-efficacy inventory was given prior to the students' interaction with CRYSTAL ISLAND - OUTBREAK. The inventory consisted of eight items answered on a 5-point Likert scale and has been shown to be internally reliable (Nietfeld, Cao, & Osborne, 2006).

Perceived Interest Questionnaire (PIQ). Situational interest was measured immediately following the students' interaction with CRYSTAL ISLAND - OUTBREAK. The perceived interest questionnaire consists of ten items measured on a 5-point Likert scale and has been shown to be internally reliable (Schraw, 1997)

Presence Questionnaire (PQ). The Presence Questionnaire is a 32-question validated measure containing several subscales, including involvement/control, naturalism of experience and quality of interface. The Presence Questionnaire is intended to measure a user's perceptions of the transparency of the actual technology. In other words, this measure provides a quantitative assessment of how immersed the user feels in the CRYSTAL ISLAND - OUTBREAK environment.

Microbiology domain knowledge was measured with a researcher-constructed, 16-item multiple-choice test based upon North Carolina Standard Course of Study curriculum and intended to measure domain-related material integrated within the learning environment. The measure was broken down into 8 fact-level and 8 application-level questions and administered before the students interacted with CRYSTAL ISLAND - OUTBREAK and again immediately following gameplay.

Microbiology Transfer Tasks. Two researcher-developed transfer tasks were created to test students' abilities to transfer skills and domain knowledge utilized in the learning environment to a similar microbiology-related task. Students completed the two, short-answer transfer tasks immediately following the interaction.

2.3 Procedure

Students completed the self-efficacy for science and gaming demographic inventories two weeks prior to the intervention. On the day of the experiment, students received a brief orientation to the CRYSTAL ISLAND - OUTBREAK environment as well as completed the microbiology content test. Students interacted with the learning environment until they completed the game or 60 minutes elapsed. Immediately following the interaction, students completed the microbiology posttest, *PQ*, and the *PIQ*.

In-game actions were recorded by the system during gameplay that included virtual book reading, consulting a microbiology field manual, conversations with non-player characters, performance on in-game mini-quizzes, testing objects for contaminants, diagnosis worksheet usage, and completion of seven major sub-goals: talking to the camp nurse, interviewing the two expert characters, talking to the camp cook, working with the laboratory scientist, testing the contaminated object with the lab equipment, and submitting a correct diagnosis worksheet. *Diagnosis worksheet* usage was quantified based upon a summed total for each entry.

Students received the most points for a correct entry, half points for an incorrect entry, and no points for not using the space at all. Also, a running, progressive score was calculated based upon student efficiency and performance during the interaction.

3 RESULTS

3.1 What Effect does Completing the CRYSTAL ISLAND - OUTBREAK Mystery have on Learning?

A hierarchical regression was performed to predict performance on the microbiology post-test. As microbiology prior knowledge was found to be highly correlated with post-test performance (r = .42), microbiology pre-test score was entered into the first block and overall presence, self-efficacy for science, diagnosis worksheet performance, final in-game score, and goals completed were entered into the second block. Both models were found to be significant ($F_{(1, 126)} = 30.94$, $p < .001$, $R^2 = .20$; $F_{(6, 121)} = 11.41$, $p < .001$, $R^2 = .36$). For the second model, only prior knowledge and number of goals completed were found to be significant predictors.

Given these results, comparisons were made between students who completed the CRYSTAL ISLAND - OUTBREAK mystery and those who did not for variables related to self-regulated learning and content learning gains. Overall, 58 students completed the mystery. An ANCOVA controlling for prior knowledge found students who completed the CRYSTAL ISLAND - OUTBREAK mystery scored significantly better on the microbiology post-test than those students who did not complete the scenario ($F_{(2, 27)} = 26.67$, $p < .001$). Moreover, students who completed the mystery reported significantly higher levels of presence ($t_{(126)} = 3.65$, $p < .001$), situational interest ($t_{(128)} = 2.45$, $p < .05$), diagnosis worksheet total ($t_{(128)} = 14.14$, $p < .001$), and performance on the transfer tasks (respectively, $t_{(128)} = 2.49$, $p < .05$; $t_{(128)} = 2.95$, $p < .01$). Finally, those who completed the mystery also had higher initial levels of self-efficacy for science ($t_{(128)} = 4.41$, $p < .001$) than those who did not finish.

3.2 How does Gender Affect Gameplay?

Prior to interacting with the environment, males reported playing games more frequently ($t_{(128)}$ = 7.91, $p < .01$) and higher levels of perceived gameplay skill ($t_{(128)} = 7.39$, $p < .01$) than females. During gameplay, males completed significantly more goals ($t_{(128)} = 2.64$, $p < .01$) and more accurately and comprehensively completed the diagnosis worksheet ($t_{(128)} = 2.14$, $p < .05$) than females. Significant gender differences in favour of males were only found for the mandatory diagnosis section ($t_{(128)}$ = 2.33, p < .05) not the hypothesis, testing, or symptoms section. Interestingly, when number of hours playing games was used as a covariate there were no remaining gender differences for goals completed or for the diagnosis section of the *diagnosis worksheet*. Also, males tended to receive significantly higher in-game scores than females at the beginning but not at the end of the interaction (see Table 1).

Table 1: Score by gender and minutes played.

Time (minutes)	Males (M, SD)	Females (M, SD)
5	34.78 (24.42)**	23.26 (18.86)**
10	90.73 (98.32)*	56.12 (66.56)*
15	115.82 (110.89)	93.05 (100.38)
20	170.93 (180.81)*	115.19 (117.45)*
25	210.38 (239.39)*	135.07 (115.71)*
30	270.10 (320.63)*	155.95 (161.56)*
35	294.04 (395.15)*	181.11 (217.39)*
40	328.33 (385.07)	236.04 (287.46)
45	378.89 (413.54)	278.51 (329.26)
50	376.56 (419.75)	301.04 (354.21)
55	428.47 (434.08)	374.61 (393.05)
60	462.21 (442.19)	355.09 (399.79)

Note: * = p < .05, ** = p < .01

Of the 73 males that interacted with CRYSTAL ISLAND - OUTBREAK 36 completed the mystery. For the males, those who completed the mystery had significantly higher levels of prior knowledge ($t_{(71)}$ = 3.05, p < .01), reported higher levels of overall presence ($t_{(71)}$ = 2.26, p < .05), situational interest ($t_{(71)}$ = 2.26, p < .05), self-efficacy for science ($t_{(71)}$ = 3.30, p < .01), diagnosis worksheet total ($t_{(71)}$ = 9.74, p < .001), performance on the microbiology post-test ($t_{(71)}$ = 4.41, p < .001) and performance on the transfer tasks ($t_{(71)}$ = 2.45, p < .01; $t_{(71)}$ = 3.06, p < .01). Of the 57 females, 22 of them completed the CRYSTAL ISLAND - OUTBREAK mystery. Considering only the female population, those who completed the mystery reported significantly higher levels of overall presence ($t_{(54)}$ = 2.61, p < .05), self-efficacy for science ($t_{(55)}$ = 2.84, p < .01), diagnosis worksheet performance ($t_{(55)}$ = 10.25, p < .001), and performance on the microbiology post-test ($t_{(55)}$ = 3.28, p < .01). No differences were found between groups with microbiology prior knowledge.

Following the interaction with CRYSTAL ISLAND - OUTBREAK, males reported significantly higher levels of overall presence than females (t (126) = 2.88, p < .01). Specifically, males reported significantly higher levels of presence for the involvement/control subscale (t (126) = 3.30, p < .01) than females, but not for the naturalism or interface subscales. Finally, comparisons of microbiology prior knowledge (M = 6.26, SD = 1.99) and microbiology posttest knowledge (M = 8.66, SD = 2.98) revealed a significant increase in scores overall ($t_{(129)}$ = 9.81, p < .001). However, no differences were found between genders for content learning gains, prior knowledge, or posttest performance on microbiology. Both genders showed significant increases in content knowledge (for boys, $t_{(72)}$ = -7.76, p < .001; for girls, $t_{(56)}$ = -6.02, p < .001).

4 DISCUSSION

Given the emerging field of on-line and computer-based learning it is essential that appropriate mechanisms are in place to encourage effective and self-regulated learning for all students. The current study reports on one particular attempt to examine overall learning and differences associated with gender within a game-based NLE.

In sum, playing CRYSTAL ISLAND - OUTBREAK led to significant content learning gains. Performance was predicted both by prior knowledge and goals completed within the game. The pedagogical approach built into the character interaction and student exploration was successful as evidenced by the fact that students who completed the mystery scored higher on the science posttest. Moreover, these students reported higher levels of engagement (presence, situational interest), strategy use (diagnosis worksheet), and the ability to transfer their knowledge than their peers who did not complete the mystery.

Interesting gender differences also emerged during interaction with CRYSTAL ISLAND - OUTBREAK. Boys who solved the mystery had different predictors of success (e.g., prior knowledge) than girls that finished. These findings suggest girls and boys may be motivated to perform well in these environments for different reasons. Also, boys entered the study with higher perceived skill and experience with computer games than girls.

Accordingly, they showed an advantage over girls in the early stages of CRYSTAL ISLAND - OUTBREAK with respect to performance (goals completed) but closed this gap to the point of statistically nonsignificant differences by the end of play. Boys still reported a higher level of presence after gameplay but no differences were found between genders on content knowledge. Boys also showed advantages for overall game score and performance on the diagnostic facet of the diagnosis worksheet yet these advantages disappear when controlling for prior experience playing games.

It is important to continue to identify such differences as reported above in order to develop gender-inclusive learning environments that promote learning and motivation for all users. From a self-regulated learning standpoint it will be important to study means by which to scaffold strategy use, metacognitive regulation, and motivational control for all students in game-based environments such as CRYSTAL ISLAND – OUTBREAK. Future research should take up this challenge of integrating effective learning scaffolds within such engaging environments because they offer a unique opportunity to customize learning for the individual learner in ways traditional learning environments cannot.

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