Girls and Games: Examining the Performance and Self-Regulation of Girls in a Science Gaming Environment

John L. Nietfeld¹, James Minogue², Hiller A. Spires¹, and James C. Lester³

¹Department of Curriculum and Instruction, North Carolina State University, Raleigh, NC
{john.nietfeld, hiller.spires}@ncsu.edu
²Department of Elementary Education, North Carolina State University, Raleigh, NC
{jminogu}@ncsu.edu
³Department of Computer Science, North Carolina State University, Raleigh, NC
{lester}@ncsu.edu

Abstract. Given the growing number of game-based learning environments (GBLEs), it is important to examine their efficacy to produce learning across genders. This study focused on girls’ performance and self-regulation within CRYSTAL ISLAND – UNCHARTED DISCOVERY, a science-based GBLE for 5th grade students. Results revealed that girls made significant learning gains for content knowledge and also performed as well as boys on a measure of game efficiency despite having less experience with digital games. Regression findings indicated the significant impact of metacognitive monitoring accuracy calibration was the strongest predictor amongst other strategy and motivation variables. In addition, higher levels of situational interest predicted in-game efficiency while seductive off-task behavior and luck attributions predicted lower levels of efficiency for girls. The findings suggest positive outcomes for girls within CRYSTAL ISLAND – UNCHARTED DISCOVERY and also suggest a number of important implications for future research of self-regulated learning within GBLEs.

Keywords: Game Based Learning Environments, Self-regulated Learning, Metacognition, Motivation, Calibration.

1 Introduction

Many factors influence gender effects on student performance, engagement, and interest in GBLEs. 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 [1]. Girls tend to prefer story development, relationships, and collaboration, whereas boys tend to prefer competition and aggression [1]. Also, the gender of characters that students interact with within virtual environments has been shown to affect student attitudes about math and science [2]. Males have been found to engage in more off-task behaviors [3], females to report higher levels of presence [4], and females, when
allowed, record greater amounts of notes [5]. The focus of this study was to examine how girls perform in one GBLE entitled CRYSTAL ISLAND – UNCHARTED DISCOVERY and also how self-regulation impacts their in-game performance. Thus far there have been few empirical investigations of self-regulated learning (SRL) within GBLEs; however, this will likely change with a recent shift in efforts to understand SRL in computer based environments [6, 7]. One study by Nietfeld et al. [8] examined SRL variables that impacted performance in a GBLE called CRYSTAL ISLAND OUTBREAK and found monitoring to be the most prominent showing significant correlations with actions completed, goals completed, and score. However, neither goal orientation nor situational interest showed relationships with important outcome variables. In this study we first sought to examine if our GBLE, CRYSTAL ISLAND – UNCHARTED DISCOVERY, supported girls learning in science. Then, we systematically measured variables that represent the primary facets of SRL including strategy use, metacognition (calibration), and motivation to examine how these variables predicted in-game performance. Previous research on CRYSTAL ISLAND – UNCHARTED DISCOVERY has demonstrated gains in content learning and self-efficacy [9], therefore we propose that it is also appropriate to examine performance within the GBLE as a dependent measure and akin to a performance-based activity in the classroom.

2 Crystal Island – Uncharted Discovery

CRYSTAL ISLAND – UNCHARTED DISCOVERY (see Figure 1 and 2) is a fully immersive GBLE where students play the role of a student-selected protagonist who is one of several shipwrecked passengers stranded on a cluster of volcanic, fictional islands trying to establish a village community. The overall goal is decomposed into three distinct sub-problems, or quests, as they are referred to within the game environment, each with two levels. A final quest requires skills and knowledge gained from the first six quests for a total of seven quests in total. The quests are self-contained adventures that challenge the student to complete game-like activities; each focus on landform identification, map navigation, and modeling, respectively, and are leveled based on difficulty. The students are free to complete the quests in any order they please; however, students must successfully complete the first level of all quests before engaging in any of the second level quests. To aid their problem solving, students can seek counsel from map and landform experts who happen to be among the shipwrecked crew as well as the player’s iPad-like device equipped with note-taking tools, a camera, a log to monitor quest completion and progress, a glossary of key landform and map skill terminology, and a problem-solving application.

![Fig 1. CRYSTAL ISLAND – UNCHARTED DISCOVERY.](image1)
![Fig 2. The student preparing to engage in a quest.](image2)
Current Investigation

A total of 293 (134 male, 159 female) 5th grade students participated in the current study (mean age = 10.87 years). Approximately 6% of the participants were American Indian or Alaska Native, 4% were Asian, 22% were African American, 12% were Hispanic or Latino, 54% were European American, and 7% identified themselves as other.

Materials consisted of the following computer-based instruments: Content knowledge. This was measured with a researcher-constructed, 19-item multiple-choice test that was based on the North Carolina Standard Course of Study curriculum and designed to measure domain-related material integrated within CRYSTAL ISLAND – UNCHARTED DISCOVERY. AGQ (Achievement Goals Questionnaire): This is a 12-item scale that measures achievement goal orientation in the form of four factors: mastery approach, mastery avoidance, performance approach, and performance avoidance [10]. Situational Interest. At the end of CRYSTAL ISLAND – UNCHARTED DISCOVERY interaction participants were asked to rate their interest in the game (“Did you enjoy this game?”) on a 10 point Likert scale with one being “Not at all true of me” and 10 being “Very true of me.” Science Self-Efficacy inventory was given as a pretest. The inventory was adapted from a previous study [11] where the scale was shown to be internally reliable and predictive of academic performance. Attributions. After playing CRYSTAL ISLAND – UNCHARTED DISCOVERY students were asked to rate to what extent each of six factors was a cause in their performance. The six factors included effort, talent, luck, my teacher, strategy use, and the difficulty of CRYSTAL ISLAND – UNCHARTED DISCOVERY. Calibration Judgments. As students were introduced to each in-game quest they were asked to provide confidence estimates on a 1 to 10 scale to rate their confidence in completing the quest. A calibration score was created by first multiplying their rating (from 1 to 10) by .1, then subtracting either zero (did not complete quest) or one (completed quest) from this number, and finally taking the absolute value of this number. We then averaged the calibration judgments across three quests for the final total. In-game activities. Two in-game activities were analyzed in the current study. One, accessing the map of the island, functioned as a measure of cognitive tool use. If used properly the map would help students to orient themselves and also to navigate and locate items on the island. The second activity, the treasure chests, were used as a measure of off-task behavior. If students approached and opened the treasure chest they could try to answer a multiple-choice question and receive a reward in the form of sand dollars. The items were related to the science content, but the activity itself was unrelated to any of the quests. In-game Efficiency. The dependent measure for performance within CRYSTAL ISLAND – UNCHARTED DISCOVERY was an efficiency measure that was computed by taking the total gameplay time and dividing that by the number of quests completed. Thus, low scores represent higher levels of efficiency.

The experiment took place during three 60-minute sessions held on three consecutive days. Two weeks prior to data collection, students completed the pretest, and the post-test items were completed immediately following gameplay.
4 Results & Conclusions

Overall comparisons of science content prior knowledge ($M = 12.27, SD = 3.79$) and science content posttest knowledge ($M = 13.08, SD = 3.85$) revealed a significant increase in scores ($t(330) = -5.70, p < .001$). An examination of prior knowledge scores and posttest content knowledge revealed no significant differences between boys and girls. However, both boys ($t(151) = -4.84, p < .001; M_{pretest} = 11.92, SD = 4.01; M_{posttest} = 12.93, SD = 4.09$) and girls ($t(178) = -3.28, p < .001; M_{pretest} = 12.58, SD = 3.57; M_{posttest} = 13.20, SD = 3.63$) showed significant within group improvement in content knowledge. In addition, no significant differences were found between boys and girls on in-game efficiency even though boys reported playing games significantly more often ($t(329) = 8.66, p < .001; M_{boys} = 3.43, SD = 1.05; M_{girls} = 2.46, SD = .98$).

Next, a multiple regression analysis was conducted to predict in-game efficiency with eleven variables that included pretest content knowledge, in-game calibration, map access frequency, treasure chest time, mastery approach, performance approach, science self-efficacy, effort attributions, strategy attributions, luck attributions, and situational interest. Variables were entered simultaneously and the model was found to be significant ($F_{(11, 117)} = 11.58, p < .001$) accounting for 72% of the variance within this sample. In-game calibration ($t = 5.39, p < .001$), time spent on treasure chests ($t = 3.60, p < .001$), luck attribution ($t = 2.63, p = .01$), and situational interest ($t = -3.30, p = .001$) were found to be significant predictors.

Results of this study suggest that elementary-aged girls can learn and perform in GBLEs at similar rates as their male peers who have more experience playing digital games. Furthermore, this study shed light on which SRL variables predict in-game performance and may provide guidance for the future development of GBLEs. Most notably, the importance of making accurate on-line judgments during gameplay was indicated by calibration judgments being the strongest predictors in our regression analysis. Given the critical importance of the accuracy of these judgments, future research should examine whether 1) the accuracy of such judgments can be increased over time, and 2) whether increases in accuracy will lead to further increased performance as the data suggests in this study suggests.

Within the SRL facet of motivation only situational interest and luck attributions were significant predictors of girls’ efficiency of in-game performance. This finding is counter to the bulk of the literature that suggests that variables such as goal orientation contribute significantly to performance. Future investigations of goal orientation within GBLEs might distinguish between observable (trace data) measures of mastery and performance orientation and self-report measures to examine differential predictive validity. Finally, even though girls had significantly less off-task behavior (as measured by treasure chest time) than boys ($t_{(326)} = 3.25, p = .001$; $M_{boys} = 229.72, SD = 134.36; M_{girls} = 184.88, SD = 115.27$), our findings reveal how important “seductive details” in GBLEs are with regard to performance. In our work over the course of numerous data collections we have observed how these types of seductive details are prevalent open-ended immersive GBLEs. However, this type of environment parallels real life as numerous activities compete for students’ time and ability to focus as they learn in various educational settings. Future studies might examine the how the systematic presentation of such details impacts performance and also explicit metacognitive scaffolds that assist students in maintaining focus.
Acknowledgments. The authors wish to thank members of the IntelliMedia Group for their assistance. This research was supported by the National Science Foundation under Grant DRL-0822200 and the Graduate Research Fellowship Program. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the authors and do not necessarily reflect the views of the National Science Foundation.

References