The Life of a Plant: Playing a Science-based Game in School

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Introduction

Genomics Digital Lab is a discovery-based online tool designed to work alongside school biology curriculum to guide Grade 7-12 science students through concepts about plant cell biology. The project entitled *The Life of a Plant*, a partnership between Spongelab Interactive and researchers at York University, was designed to administer the game in a variety of classroom environments throughout schools in southern Ontario. Using only technology available in the schools, the students played GDL in a group setting in order to evaluate the game's ability to engage students and assist them in understanding material about plant cell biology.

This report is a result of visits to 5 secondary schools in southern Ontario: Eton Secondary School, Culloden Secondary School, Preston College, St. Jude's Catholic Secondary School, and the York School[1]. These secondary school sites included 2 public schools, 1 private school, 1 Catholic school, and one alternative school. Data was gathered through a mixed-methods approach, including: observation, informal interviews with students and teachers, video recording of gaming sessions, pre and post-quizzes to evaluate material students retained from the game and game metrics collected by the Spongelabs server. In total, there were 13 gaming sessions in 10 classrooms in the 5 schools. Working with 7 teachers, 160 students played GDL and 147 students completed pre- and post- quizzes. Approximately 18 hours of observations were recorded.

Research Questions

This report summarizes quiz data and the questionnaire data in tandem with observational and video-based qualitative work. The questions that framed the research project are:

1. What difference (if any) does it make to students' understanding of plant cell biology if they play GDL?
2. How much information do different groups of students retain about plant cell anatomy and photosynthesis after playing GDL and what are the factors that can contribute to making the use of GDL more successful?

    a. How does the classroom environment including student demographics and teacher involvement affect the reception, efficacy and use of the game?
    b. How does the available technology as well as student and teacher technological ability affect the reception, efficacy and use of the game?

Design

The study design was quasi-experimental. Students were split into two groups: one group received a 10 minute introduction of the material before the pre-game test was administered and one group did not. Each class played the game for 30-40 minutes (times often varied because of computer set-up), and were then administered a post-game quiz. The lesson that each class played (Lesson 1: The Plant's Environment Game and the introduction level of GDL; Lesson 2 Quiz: The Light Reaction Game and the Calvin Cycle Game) and number of days they participated in the study was determined by

[1] The names of the participating schools have been changed to maintain anonymity.

availability of the class and the discretion of the teacher. *Table 1* below summarizes participation at each site involved in the study.

Table 1: Site Participation

Class	Site	No. of Students	Grade Level	Days	Lessons	Presentation
1	1	20	9	2	1	Yes
2	1	13	12	1	Transcription	No
3	2	26	9	2	1 & 2	Yes
4	2	19	10	2	1 & 2	Yes
5	2	19	10	2	1 & 2	No
6	3	15	9	1	2	Yes
7	3	13	9	1	2	No
8	3	14	9	1	2	Yes
9	4	6	9	1	2	No
10	5	15	12	1	2	No

Sample

10 grade 9, 10 and 12 classrooms participated in the study with class size ranging from 6 students to 26 students (see *Table 1*). The majority of student participants (42.5%) were age 15, 28.8% were age 14, 10% were age 16, 10% were age 18, 8.1% were age 17, and .6% were age 13. 48% of the students were male and 52% of the students were female.

Students were also asked to report aspects of their technology use. Almost all of the students (96.25%) reported that they have a computer at home with internet access while 80% reported that they own a cell phone. 92% of the students reported that they play video games, of these students 20% said they play once a month, 26% said they play once a week, 33% said they play 3-5 times a week, 19% said they play every day, and 2% did not answer the question. When grouped by sex, there was a significant difference between boys' and girls' reported play patterns. 8% of boys reported that they play video games once a month, 27% reported once a week, 41% reported 3-5 times a week, and 24% reported that they play every day. 33% of the girls reported that they play video games once a month, 25% reported once a week, 26% reported 3-5 times a week, and 16% reported that they play every day.

Methods

Quantitative Data

Data was collected qualitatively and quantitatively. The quantitative collection included a questionnaire that gathered data about student demographics and experience with video games, a pre and post-game quiz and game metrics collected by the game and stored on the Spongelabs server.

Each quiz had 10 questions: 6 multiple choice and 4 true and false that were based on Grade 8—Grade 10 Ontario biology curriculum and game content from two levels of Genomics Digital Lab. The first

quiz tested concepts related to the Plant's Environment Game in the introduction level of GDL. The second quiz tested concepts related to the Light Reaction Game and the Calvin Cycle Game (both found in the Intermediate level of GDL under Lesson 2). The questions on the quiz were designed to gauge student attention animated introductions, understanding of graphics and their correlating labels and to what degree they explored the game site.

Game metrics collected and stored on the Spongelab server included where the game was accessed, the time of day it was accessed, times each game was played, the maximum time (in minutes) it took to complete each level of each game accessed as well as the score for each game and each level. Also included in the game metrics were comparisons of each student to their classroom and to other students throughout the world. For the purposes of this study, four of the available figures were used for each level of each game: 1) time; 2) place the game was accessed; 3) number of times played; and 4) maximum time to completion.

Qualitative Data

Qualitative data was collected in order to supplement quantitative data, explain any trends in quantitative data, and gather important information about the field sites. Qualitative data collection included informal interviews with teachers, video recording of the gaming sessions, informal interviews with the class after gaming sessions, and observations by the researchers. The gaming sessions were video recorded with two cameras: the first was stationary and the second was mainly carried by one of the researchers to interview the students while they played. At the end of data collection, the researchers made logs for each video that detailed what happened in the classroom during the sessions, how the students were playing the game (if computer screens were visible in the video) and any discussion of the game and game material.

Qualitative Data Analysis

Analysis 1

For the purposes of this study, the participating students' understanding of plant cell biology was evaluated by the 10-question pre and post quizzes-described in the Methods section of this report. Once the data was tallied each students' pre and post quiz-scores were recorded and compared to determine if their knowledge of the quiz questions improved after they played GDL.

Data analysis was run twice: in the first set of tests the students' scores were grouped into 1) those that answered more questions correctly on the post-quiz than the pre-quiz and 2) those that did not (which includes those who answered the same amount of questions correctly. The first set of tests were run to determine correlation coefficients between these two groups and the variables.

Analysis 2

Since there were so few significant relationships found in the first analysis the data was reconsidered, and the researchers discovered that because Culloden Secondary School finished their Lesson 1 games quickly and moved on to the Lesson 2 games on the first day of the study, they became familiar with Lesson 2 game content before they took the Lesson 2 pre-quiz. As the scores of the Lesson 2 quizzes for Culloden Secondary School do not accurately reflect students' knowledge of the quiz material before and after they played the game, these scores were omitted from the second data analysis. To allow for more variance, the students' scores were also regrouped into 3 categories according to whether the student: 1) answered more questions correctly on the post quiz than the pre quiz, ("higher"); 2) answered the same amount of questions correctly on the post quiz than the pre quiz ("same"); or 3) answered less questions correctly on the post quiz than the pre quiz ("lower").

Findings

Qualitative

Analysis 1

The first data analysis revealed that Lesson 2 score improvement was associated with grade level. There was an association between score improvement and those who spent more time playing the game, most notably, there was a strong correlation between improvement in game score and time spent on the game. There was also a weak correlation between Lesson 1 quiz score improvement and the amount of time the student spent on the anatomy explorer, and there were moderate correlations between Lesson 2 quiz score improvement, the amount of time the student watched the intermediate level animation and the amount of times the student played the Light Reaction Game Level 1 and 2. There was no statistical significance between gender and those that scored higher on the quiz.

Analysis 2

After playing Genomics Digital Lab, 69 out of 161 students scored "higher," 32 students scored the "same" and 30 students scored "lower" on the quiz. In total, 53% of the students who participated in the study improved their quiz scores by playing GDL. Moreover, each class had a higher percentage of students that improved their scores on the quiz after playing GDL, with the most notable improvement at St. Jude's Catholic High School, where 100% of the class improved their quiz scores. Paired T-Tests were conducted to determine within-subject effects of the pre-quiz and post-quiz scores for Lesson 1 and Lesson 2. The difference in the pre and post-quiz scores for Lesson 2 are statistically significant.

Quantitative

Teachers

Although some of the teachers were initially reticent to participate in the study because the game content did not directly relate to the curriculum the students were learning at the time, in the classrooms where the game ran smoothly the teachers seemed pleased with the game and the students' interaction with it. The teachers' different ways of introducing and receiving the game seemed to work in favour of data collection except for an instance: a teacher's alternate (laborious) assignment that was designed to "motivate" students to bring in their consent forms seemed to contribute in a negative attitude towards the game as well as general inattentiveness.

Classroom Environment

It was clear that the categories teachers' gave us for their classes, applied, academic, enriched, etc. did not have much to do with the students' engagement or success with the game. Moreover, the grade level of the students did not have any statistical significance. Classroom dynamic, especially students' patience, focus and willingness had the most impact on how students did, and whether or not they actually played. However, it is important to mention that the classroom attitude was often related to how smoothly the technology worked; if the students had cause to be excited and the game ran smoothly, they were often willing to give it their attention.

The Technology

The available technology and the level that it worked at was the single most important factor in the

study. It had the potential to discourage participants or cause them to lose interest quickly. Especially during repetitive stages of the game when students' patience was already wearing thin, it was imperative that the technology worked or the students were likely to quit, move on to another game or do something else. Most surprising was the fact that the schools with the most resources were not the schools who had the best access to the game: the classrooms where the game worked the best were at a public school with a computer lab of PCs with an updated flash player. The Catholic School with a computer lab had problems loading the game and with the game freezing, the private school with personally issued laptops had excruciating loading times and were often slow, the public school with a laptop cart required a higher network speed than was available wirelessly, and the alternative school had a mixture of computers, none of the Macs worked, and the internet connection was too slow to even load through to the Main Menu.

Student impressions of the game

As expected, most of the students were excited to be participating in an alternate activity during their regular class time. This made them more than willing to play Genomics Digital Lab, whether or not they expected to learn. A large number of students did, however, appreciate the interface of the game, the visual and auditory cues, and the alternative learning style offered by the game. In other words, more than just not being in class, the students enjoyed the game. The students appreciated that the repetition helped them to memorize components of the games, they also commented that they liked the music, animation, and graphics. There were also consistent complaints and criticisms about areas of the game that clearly discouraged the students from fully engaging, that is, they expressed frustration with areas of the program that seemed finicky, included too much repetition and were difficult to navigate. In addition to these criticisms, the researchers noticed that participants were often able to tell us how to win the game but not what was happening beyond the game mechanics, meaning that the labels for the pictures that represented molecules, organelles, protein complexes, etc. were not clear or large enough, nor was their function necessarily clear.

Discussion

At least preliminarily, we can surmise given this data that Genomics Digital Lab is a successful tool for understanding material related to plant cell biology. That is, *53% of the students that played Genomics Digital Lab improved their quiz scores and those that played the game longer were more likely to improve their quiz score*. Moreover, the class at St. Jude's Catholic School, using the photosynthesis games in GDL (Lesson 2) as a review for their final exams, *improved their scores by 100%*. The improvement in Lesson 2 quiz scores overall was also statistically significant, indicating that playing GDL helped students to improve their quiz scores on Lesson 2.

Perhaps most astonishing were the findings related to the introduction to the game material. Half of the participating classrooms were presented with a 10 minute interactive lesson that introduced the graphics, vocabulary and processes involved in the game. When the quiz scores of the students who received the introduction were compared with those who did not, there was *no statistically significant difference between the two groups*. In other words, the students that had an introduction to the game and curriculum content before playing the game did not score better on the post-game quiz.

Besides confirming the efficacy of GDL, the findings suggest that: 1) the photosynthesis games in particular are likely to help players retain knowledge (at least temporarily) about the material; 2) GDL might be most successfully used as a review tool; 3) because there was no statistically significant difference between the score improvement of any of the classes, it is clear that GDL is equally

successful in grade levels 9, 10, and 12 regardless of whether the game material is a part of a student's curriculum; and 4) the game is equally successful as a stand alone tool and as something integrated into the lesson.

The self-reported information about gaming indicated that video gaming skills are not necessarily transferable to GDL games. The boys in the sample responded that they play video games more than the girls: 65% reported that they play more than once a week while 42% of girls reported that they play more than once a week. The fact that there was no statistical significance between gender and those that improved their quiz scores leads the researchers to conclude that being an advanced gamer (as the boys self reported) did not give anyone an advantage playing Genomics Digital Lab. This can be attributed to the game mechanics mainly involving point and click or point and drag activities which lead to students playing the levels quickly without necessarily paying attention to game content. Because the students played through the games quickly, whether or not they understood the content, with more concern for the playability and challenge of the game mechanics, it might well be that the game works better as a one day activity, or as a review tool, as students tended to lose interest over more than one play session.

The game proved to be useful despite technology issues, but it is also clear that in order for the students to have a positive experience with Genomics Digital Lab, one must consider the availability of the resources. Certainly for a special presentation and a research study, computers can be reserved. But for the day to day curriculum which is to include GDL or games like it, teachers may not be willing to go to the trouble of finding, reserving, and troubleshooting the technology, especially if they are responsible for making sure the gaming session goes smoothly. It might therefore be useful to consider the game as less of a classroom activity and more of a small group/solitary or enrichment activity for those who have access to the required technology and the time to make sure it is functional.