Do Girls and Boys Come From Different Planets? Gender Differences in Educational Games

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Abstract: Research shows that, on an average, a teenager spends 14 hours per week playing video games. But there are studies that say that there is a discrepancy between male and female counterparts in their attitude towards video games in general. According to the entertainment Software Association (ESA), the number of girls vs. boys as video game players is changing in the recent times. This study investigated the following research questions: (1) Do instructional games augment learning for both female and male students? (2) What is the impact of the challenge and fantasy features in instructional games on learning for both female and male students? The overall result shows that the gender has no significant impact on learning. But the gain score for the female students who played a version of the game, in which fantasy turned-on is significantly higher than male students.

Introduction

Students' achievement in math and science is on the decline in the United States. National Academies (2007) mentions "the critical lack of technically trained people in the United States can be traced directly to poor K–12 mathematics and science instruction" (p. 114). Further, it elaborates "few factors are more important than this if the United States is to compete successfully in the 21st century" (p. 114).

Why is investing in science and math education important? National academy of Sciences in their 2007 report entitled *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future*, answered this question in the following manner: "today, much of everyday life in the United States and other industrialized nations, as evidenced in transportation, communication, agriculture, education, health, defense, and jobs, is the product of investments in research and in the education of scientists and engineers" (p. 41).

Educational Games in Science Education

Learning through games is not a new phenomenon. According to Bradshaw and Lowenstein (2007) the use of games for learning is a rather ancient technique. For example, games were used to coach soldiers for war. For the past three decades scholars (Nelson, 2008; Terenzini & Pascarella, 1994) predicted that traditional tools such as class lectures, reading and writing assignments, tests, field trips, discussions, laboratory reports, and such others, for teaching science may not be effective teaching tools. On the contrary, new instructional techniques such as using video games make "players think, talk, and act" and their rich virtual environments are what make games powerful contexts for learning (Shaffer, Squire, Halverson, & Gee, 2005). Squire and Jan (2007) said that schools lag behind in producing appropriate learning in today's knowledge-based economy:

> Science education needs to prepare students for a future world in which multiple representations are the norm and adults are required to 'think like scientists.' Location-based augmented reality games offer an opportunity to create a 'post-progressive' pedagogy in which students are not only immersed in authentic scientific inquiry, but also required to perform in adult scientific discourses. (p. 5)

While concluding, Squire and Jan mentioned that augmented reality games on handhelds "hold the potential for engaging students in meaningful scientific argumentation" (p. 5). The same idea was reiterated by Goodman (2007), that a game-based education might actually prepare students to face real world problems.

Study Purpose

This study has two main purposes: first to find out whether instructional games support effective learning for both female and male students, and secondly to determine whether the factors of challenge and fantasy in instructional games impact learning outcomes. The theoretical framework for educational games is based on constructivism. One of the main tenets of constructivism is that students construct their own knowledge. As Bruner (1966) mentions:

> The will to learn is an intrinsic motive, one that finds both its source and its reward in its own exercise. The will to learn becomes a 'problem' only under specialized circumstances like those of a school, where a curriculum is set, students confined and a path fixed. The problem exists not so much in learning itself, but in the fact that what the school imposes often fails to enlist the natural energies that sustain spontaneous learning. (p. 127)

It is evident from Bruner that educators need to provide environments that would intrinsically motivate students to construct their own reality. Games are intrinsically motivating. That is there is no external reward needed for the intrinsic motivation. But the experience of the activity in itself is gratifying. Salen and Zimmerman (2004), said that games provide pleasure, which is intrinsic and that cannot be easily explained but something people desire to experience. Some might argue that players play games to win. If winning is the sole motivation for participating in games, probably the Olympics by this time would have been reduced to an arena of couple of dozen countries. Several countries participate in the Olympics despite not getting even a single medal for several years, because they want to participate in the game for the sake of participation. Such a naturally motivating technique can be effectively used in learning environments.

Essential Features of an Educational Game

There are scholarly articles (Malone, 1981a; 1981b; Malone & Lepper, 1987; Dickey, 2005; Kirkley & Kirkley, 2005; Shaffer, 2007) published in the last 30 years that mention the important features of games. Malone's (1981) seminal work, which has been quoted in many scholarly articles, identified three important characteristics of intrinsically enjoyable computer games:

1. Challenges
2. Fantasy
3. Curiosity

In the Curiosity category, Malone mentioned that informative feedback is one of the specific principles needed for designing games. There is sufficient literature to support the role of feedback in an instructional environment. The current study was intended to find the impact of challenge and fantasy in an instructional game.

Challenge

Studies show that challenging activities improve student engagement not only in games but in classrooms as well. Shernoff, Csikzentmihalyi, Schneider and Shernoff (2003) concluded that students experience increased engagement when they encounter a highly challenging activity and perceive that they have the appropriate skills needed to complete the task.

After conducting a study that involved more than 40 educational games, Dempsey, Haynes, Lucassen and Casey (2002) reported that "learners are likely to sustain interest in games that are challenging and goal oriented" (p. 166). Fong-Ling, Rong-Chang and Sheng-Chin, (2009) concluded, after evaluating four instructional games, that challenge is one of the main factors that makes an educational game effective. Lucas and Sherry (2004) studied gender differences in video game play and reported that for both male and female players, challenge is one of the top-ranked gratifications to play a game. Video game players enjoyed being faced with challenging and competitive circumstances and it was one of the fun elements of video games (Vorderer, Hartmann & Klimmt, 2003). The human need to have challenges is rooted in a desire to achieve, which goes back to McClelland, Atkinson, Clark, and Lowell (1958) theory of achievement. McClelland et al. (1958) defined the need for achievement as "success in competition with some standard of excellence. That is, the goal of some individual in the story is to be successful in terms of competition with some standard of excellence" (p. 181). This idea was echoed by Daft (2008) who says that achievement is "the desire to accomplish something difficult, attain a high standard of success, master complex tasks, and surpass others" (p. 233).

Fantasy

Cassell and Ryokai (2001) posited that fantasy plays an important role in a child's development. Through fantasy activities such as role-playing, dress-up, and storytelling with objects such as stuffed animals, children explore different possibilities in their life without the

risk of failure and frustration. Thus fantasy plays an important role in children's emotional and social development. Further, fantasy also fosters children's cognitive and language skills. By fostering the development of children's symbolic imagination and providing a field for its exercise, fantasy play and narrative activity prepare the way for the development of abstract thinking and higher mental processes (Cassell & Ryokai, 2001).

Kenny and Gunter (2007) argued that it is essential for both game designers and instructional designers to use the fantasy feature properly. Fantasy plays an important role when a player decides whether to play a game or not. Players might choose a game that has a strong and interesting fantasy. Similarly, in an educational context also, learning content coupled with fantasy is more appealing and leads toward a better retention of the modules learnt (Kenny & Gunter, 2007). Game designer Marc LeBlanc (2004) defined fun using eight different terms and fantasy is one of them. He said fantasy is the make-believe aspect of a game that resonates with the gamer and thereby makes the game more enjoyable.

Study design

Studies that include more than one factor or variable are known to follow factorial design. In this study, following are the independent variables:

1. Features (has four levels: challenge on, fantasy on, both on and none on),
2. Gender (has two levels: Female and Male)

To find out the main effects of features, a univariate analysis was used. To find out the individual differences the researcher used the X x Y factorial design model in this study. Factorial design not only tests the significance of group differences (due to the levels of the IVs), but also tests for any interaction effects between levels of independent variables (Mertler & Vannatta, 2010). In the current context, factorial design not only tests how challenge and fantasy features affect the learning outcome, but also tests the combined effect of gender on the learning outcome measured by the gain score.

A game called *Humatan* was created to teach human anatomy to high school students. *Humatan* is an instructional game where high school students will learn to identify and assemble human skeletal structures. This game is specifically developed to address the following standards of Baltimore County Public Schools (BCPS) curricula:

1. Para-medical Biology: The Human Body (20.4)
2. Human Anatomy: Support, Protection and Movement (12.3) of the BCPS Curriculum

Humatan game

It is 1369 BC. King Akhenaton is Egypt's ruler, with Queen Nefertiti by his side. They don't have any children yet. A learned scribe has told the King that the ancients had been aware of this time, and had with their immense skills created two little human bodies, that of a male child, and a female child, with all the body parts, separated and hidden away in the royal palace rooms long ago. This scribe knew how to pray to Lord Anubis to bring the children back to life, provided they could find for him or her all the body parts, which were hidden in the palace, and assemble them together.

It is now up to the player to find all the parts, and get them to the courtroom, and fix them correctly to make the new heir to the throne come alive. The player is made aware that during the quest there could be all sorts of danger lurking everywhere.

The *Humatan* game was made in such a way that the various instructional aspects (variables) were turned on and off. Following four variations of the game were created and students were randomly assigned to play each variation of the game:

1. One game with Challenges alone (No fantasy)
2. One game with Fantasy alone (No challenges)
3. One game with both variables
4. One game with none of the variables

The game was tested by the BCPS Office of Science PreK-12 for its content and usability. Students initially took a pretest and played the *Humatan* game followed by the posttest. Both pre and posttests consist of following tests:

1. Identification test (to assess student ability to identify the skeletal parts)
2. The Terminology test (to assess whether students could identify the bone and its common name)
3. Comprehension test (to evaluate students' knowledge of specific parts of the human body associated with specific skeletal structure)

Results

A total number of 254 students from nine high schools in BCPS participated in the study. Out of 254 students, only 202 students successfully completed all the steps (taking the pretest, playing the game and taking the posttest) of the data collection. The remaining 51 students took only the pretest and played the game, but were unable to complete the posttest. Out of 202 students, 121 were the female and 79 were male and 2 students did not report their gender.

Statistical analysis

Reliability test for the pretest and posttest was conducted and the Cronbach Alpha coefficient was .889, which shows that both tests have a good internal consistency by conventional standards.

A paired samples t-test was conducted to see if there is a significant difference between the pretest and posttests and the findings are reported in Table 1:

	Mean	N	Std. Deviation	Std. Error Mean
Pre Score	11.80	202	5.703	.401
Post Score	15.20	202	5.892	.415

***Table 1*: Paired Samples Statistics**

From the paired samples t-test results we can see that there was a significant difference in the posttest scores (M=15.20, SD=5.892) and the pretest scores (M=11.80, SD=5.703); t (201) = -13.182, p = 0.000. These results suggest that *Humatan* game does facilitate learning. Specifically, the results suggest that when students play an instructional game, their learning does increase as reported in the posttest scores. Also, there is a strong positive correlation (r = .800), which indicates that the students who did well on the pretest also did well on the posttest.

Gender

A two-way between-groups analysis of variance was conducted to find the effect of game features and gender on gain score. A total of 121 female students and 79 male students participated in the study. Table 2 shows the mean scores of each gender in different game versions. Four groups of students played four different versions of the game containing the following features: Both On, Challenge On, Fantasy On, and None On.

Dependent Variable: Gain Score

Feature	Gender	Mean	Std. Deviation	N
None on	Female	3.0938	3.37313	32
	Male	2.7778	3.60646	18
	Total	2.9800	3.42553	50
Challenge on only	Female	5.5185	3.57739	27
	Male	4.3500	2.94288	20
	Total	5.0213	3.33942	47
Fantasy on only	Female	3.4688	4.71774	32
	Male	1.6316	3.33684	19
	Total	2.7843	4.31423	51
Both on	Female	2.9333	2.91173	30
	Male	2.9091	3.39340	22
	Total	2.9231	3.09234	52
Total	Female	3.6942	3.80973	121
	Male	2.9367	3.39812	79
	Total	3.3950	3.66279	200

***Table 2*: Descriptive Statistics**

The interaction effect between gender and game feature was not statistically significant, F (3, 192) = .65, p=.59. There was a statistically significant main effect found for feature F (3, 192) = 4.26, p=.006. Post-hoc comparisons using the Tukey HSD test indicated that the mean score for the challenge feature (M =5.02, SD =3.43) was different from none on feature (M = 2.98, SD =3.43). Both on (M = 2.92, SD = 3.09) and Fantasy on (M=2.78, SD = 4.31) features did not differ significantly from either challenge or none on. The main effect of gender, F (1, 192) = 2.61, p=.11, did not reach statistical significance.

Figure 1 is a graphical representation of the mean gain scores achieved by male and female students for different variations of the Humatan game.

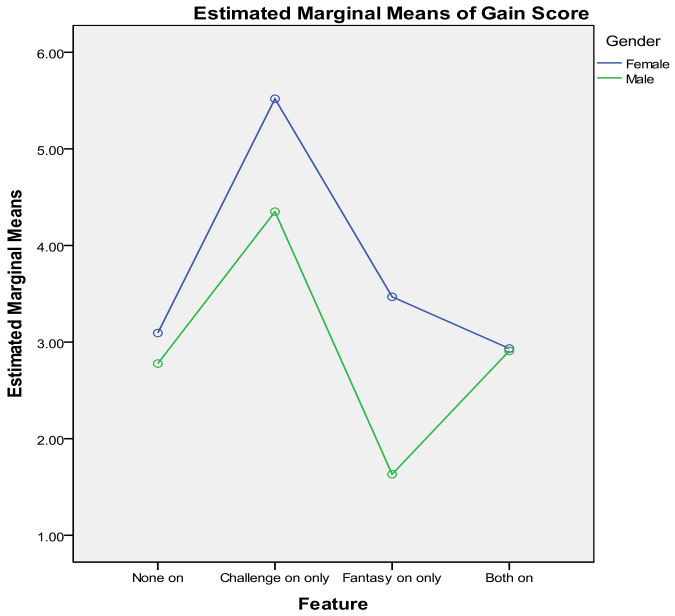

***Figure 2*: Profile plots for the different variations of the Humatan game based on gender**

Discussion

Current study results show that games with challenges make students learn better, probably because they feel a sense of achievement irrespective of their gender. On the other hand, fantasy feature helped female students to learn better (M = 3.46) than the male students (M=1.63). As mentioned earlier, the interaction effect between feature and gender did not attain statistical significance, which shows us that there is no significant difference between male and female students in the overall increase in achievement scores.

This study results are in concurrence with those studies in which no significant difference was found between the male and the female students while using an instructional game. Annetta, Mangrum, Holmes, Collazo, and Cheng (2009), in their study did not find any significant difference between male and female subjects. Similarly, Ke and Grabowski (2007) tested the differential effect of games on the math achievement of 5th-graders of two genders. The study did not observe the main effect for gender or interaction effects between gender and computer games on the math achievement of 5th-graders. Papastergiou (2009) investigated the effects of computer games on science achievement of 88 high school students and found no gender-based differences.

From the current study results we can conclude that challenge is a very important feature and it positively augments learning in an educational game. Endogenous fantasy is a helpful hook to attract the students (especially female students) towards an educational game. However, if the fantasy element is too compelling, then the game might become less educational, and more entertaining, which is inferred from the low gain scores of the male students. Individual differences due to gender was not significant in the study, which tells us that the importance of design features is extremely crucial for a successful instructional game and if the game features are properly designed, then the individual differences among the students do not impact the learning significantly.

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