Does Gamification Work for Boys and Girls? An Exploratory Study with a Virtual Learning Environment

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ABSTRACT
The development and use of Virtual Learning Environments (VLE) has increased considerably over the past decades. Following that trend, many research findings have shown the benefits of using VLE during the learning process. Nevertheless, there are important problems that hinder their use requiring further investigation. Among them, one of the main problems is the inappropriate use of these systems by students. The boredom, lack of interest, monotony, lack of motivation, among other factors, ultimately causes students to behave inappropriately and lead them to a lower performance. In this context, the proposed study investigates whether it is possible to reduce undesirable behaviors and increase performance of students through the use of game mechanics (i.e. gamification). We develop a VLE, *E-Game*, that can turn on/off several game mechanics, such as points, badges, levels and so on. A case study was conducted with two groups of students to investigate their behavior during their interaction with *E-Game* with and without gamification. The results indicate that the gamification implemented by *E-Game* contributed to improve student performance in the case of boys. Yet, improvement was not observed in the case of girls. Furthermore, it was not possible to conclude whether the use of gamification helps to prevent inappropriate student behavior, and therefore, further studies and experiments are needed.

Categories and Subject Descriptors
• Interactive learning environments; Interactive games

General Terms
Experimentation, Human Factors

Keywords
e-learning, gamification, gender difference, gaming the system

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1. INTRODUCTION
The design, implementation and use of game mechanics in non-game contexts is known as "*Gamification*" [5]. It involves the use of aesthetics, mechanics and dynamics in contexts unrelated to games, to increase motivation and support behavior change. Currently, there is an increasing interest in using gamification in educational contexts due to the amount of applications and research in this area [12,16]. This growing interest can be explained mainly by the potential of gamification to influence, engage and motivate people [14].

Studies about the use of games and game mechanics in education have been conducted for decades [17]. Nevertheless, the interest in the topic has increased considerably in the past few years due to the potential of using game mechanics in virtual learning environments (VLE) to reduce students' dropout rates and increase their motivation and participation in online learning activities [15].

Several researchers suggest that students who use VLE, particularly intelligent tutoring systems, often learn more and improve their performance and knowledge retention compared to students in conventional classrooms [1,11,14,20]. However, in some cases, factors such as lack of student motivation, boredom or dissatisfaction with a discipline directly affect the proper use of these systems [2]. A behavior called by Baker et al. [2] as "*Gaming the System*" manifests itself when students ignore the essence of the learning activities, and find ways to complete them mechanically without learning the content. Numerous efforts have been described to detect this type of behavior [3, 4, 6], to perform some sort of content adaptation that makes it difficult and even eliminate the continued use of inappropriate behavior [7]. However, no one so far has attempted to prevent this type of behavior by increasing students' motivation and desire to learn as well as their commitment to their learning process.

According to Cytowic [8] cognition, memory and decision making capacity of the individual are intrinsically linked to emotions. Studies show that students who feel anxious, upset or depressed do not assimilate information properly and because of that, eventually develop inappropriate behaviors that hinder learning [3, 13]. In contrast, students who feel motivated, challenged and intrigued tend to get better results. Yet, keeping

students motivated throughout the whole learning process is considered one of the major challenges in all forms of learning. According to Vassileva [21], it is possible to incorporate mechanisms and tools in the design of applications that can motivate users and change their behavior in a desirable way.

In this context, we intend to investigate whether the use of gamification can help to reduce the inappropriate behavior of students and also improve their performance in VLE. For that, we developed the *E-Game*, a gamified educational virtual environment that rewards students' successful performance with points, badges, and levels. A controlled study was conducted with two groups of students in order to investigate their behavior when interacting with E-Game with and without game mechanics. The study aims to analyze the use of game mechanics in educational systems to improve students' performance during the learning process and to reduce the occurrence of undesirable behaviors, such as Gaming the System.

2. RELATED WORK

In this section, we present an overview of related work about undesirable behaviors occurring during the use of virtual learning environments and about increasing students' motivation through gamification and game mechanics. We conclude by presenting a brief overview of the game mechanics chosen to use in this work.

Undesirable behavior

There are many behaviors in which learners may engage during the use of an educational system. To identify those behaviors, several studies were considered [2,3,4,6]. According to the literature, several behaviors, such as gaming the system and lack of interest, are considered undesirable because they affect negatively the learning process during the use of an educational system. Baker et al. [2] describe a family of behaviors that he called "Gaming the System", which makes the student ignore the content to be learned to find short cuts to mechanically perform learning activities proposed by the system. In other words, the student has found different ways to cheat the system to get the right answer, or to get a better performance without learning the content. In this aspect, "Gaming the System" is considered the most problematic undesirable behavior, since it affects directly the process of learning and by cheating the virtual learning environment, it is difficult to verify whether the learner is studying properly, but not learning, or behaving like someone who is studying properly, but in fact he/she is not.

Motivation through Gamification

Gamification is the integration of game mechanics in non-game environments to increase audience engagement, loyalty and fun [10]. Although the term of "Gamification" is new, it is directly related with the concept of games and game mechanics, which has accumulated a number of patterns, rules and feedbacks that create user engagement, are motivational and can be applied to develop game-like mechanics in any application, including educational environment [21]. According to Vassileva [21], the most commonly used game mechanics are summarized in Table 1.

Table 1 – Patterns of Game Mechanics

PATTERN	DESCRIPTION
Ownership	Allowing the user to own things, such as points, token, badges. It creates loyalty to the system.
Achievements	Providing a virtual or physical representation of having accomplished something that can be easy, difficult, surprising, funny, and accomplished alone or as a group.
Status	Computing and displaying rank or level or a user.
Community collaboration and quests	Posing challenges to the users related to time-limit or competition, that can be resolved by working together.

Kapp [15] defines different patterns that he calls "Game Elements", which the games are based on, and the combination of which largely determine the success or failure of the game. According to Kapp [15], some of the common Game Elements are players, abstraction, rules, feedback, quantifying results, emotional results, storytelling, among others.[1]
Those elements used independently don't make a game interesting. However, combining game elements can make a difference to increase the motivation and the interest in the system. Given the research about Gamification, some of the game mechanics were chosen to be used in the development of a virtual learning environment, which is part of this study. The game mechanics, combined with patterns of game mechanics, used in this work are shown in Table 2.

Table 2 – Patterns and Game Mechanics chosen

PATTERN	GAME MECHANICS
Ownerships	• Points • Badges
Achievements	• Feedback • Emotional Results • Challenge • Rules
Status	• Ranking

This combination has the goal to avoid or reduce the externalization of undesirable behaviors such as Gaming the System by motivating the student and keep the loyalty between the player and the game.

3. EVALUATING THE GAMIFICATION

This section presents the development of a gamified educational virtual environment, E-Game, which implemented all the gamification mechanics chosen in Table 2. Also, it describes the experiment to test the impact of gamification on undesirable learner behaviors and learner achievement that we carried out using E-Game as a tool. Finally, it discusses the experimental results.

3.1 Development of E-Game

E-Game was designed to be an environment for support math teaching and learning process, to virtually support a classroom and distance learning environment. Moreover, the environment includes the concepts of gamification in an attempt to prevent or reduce the student's behaviors of Gaming the System. It is possible to create courses and add tasks for each course, where the students login and complete the tasks assigned to them in a fun environment. Also, E-Game supports video uploads so the teacher can add to help the students during their tasks.

The following game mechanics were implemented:

[1] Different authors call game mechanics as "game elements". For this work, the terminology and differences are not relevant.

•**POINTS**: Each user collects points for each question answered correctly the user will receive (10 points).

•**BADGES**: The badges are indirectly related to the points. The student receives different badges according to the number of questions he/she answers correctly.

•**FEEDBACK**: In each question, the system shows 3 buttons that the user can click: "Help", "Check" and "Continue". Before continuing to the next question, the user has to check if the answer is correct pressing the "Check" button, and the system gives the immediate feedback to the user, showing the correct, in case the answer is wrong. Also, the user can click on the "Help" button, and it will show a popup with some tips to help answer the question. However, the tips have a cost for the user of 5 points from their points score. In this way students are discouraged from requesting Help without even trying to answer the question (one of the gaming behaviors identified by Baker et al. [2]).

•**RANKING**: The ranking of students is based the points won by them so far. The sidebar menu hosts the ranking, so it is visible all the time. The ranking also shows the avatar chosen by each student, and how many points they have.

•**EMOTIONAL RESULTS, CHALLENGE, RULES**: those game mechanics are intrinsically implemented and it appears during the use of the system itself. The emotional results are consequence of the feedback and the questions to be answered; the challenge and rules are explained in the beginning of the system before they started, and could be checked at anytime during its use.

Figure 1 show the instructions page after the login, where it explains how the learning environment works. Currently, it implements with only 3 game mechanics, yet E-Game allows incorporating different ones, if needed. In the left side (Figure 1), the menu bar shows the points, progress bar, badges and ranking of each student logged in. The top contains the number of correct and incorrect questions during the use, and also a link to the profile page, which can be accessed anytime.

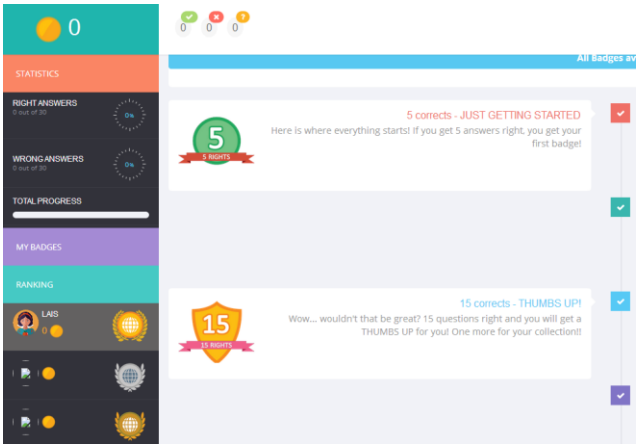

Figure 1 – E-Game Educational System: screenshot of the Instructions page

3.2 Experiment

In order to evaluate the effects of game mechanics and game mechanics to discourage the student to game the system, we have developed an experiment using the E-Game in a school from the Catholic School System, in Saskatoon, Canada. More specifically, we designed the experiment to examine whether the gamified E-Game (i.e. which has all the game mechanics implemented) reduces the occurrence of students' behaviors of gaming the system and improves the students' performance in comparison to the non-gamified version (i.e. a version of E-Game without the game mechanics). Thus, our research questions (**RQ**) can be formulated as the following:

RQ_1: Does gamification with points, badges, feedback, and ranking increase the motivation and help to discourage the student gaming behaviors during the use of the educational system?

RQ_2: Do the game mechanics increase the learning performance of the students during the use of the educational system?

3.2.1 Goal Definition

The case study was conducted in a class of 16 seventh graders (7 girls and 9 boys, ages 12-13) who were using the educational system E-Game. The class was divided in two groups of 8 students randomly, one using the gamified educational system and the other group the system without game mechanics. Since we are aware that with 16 students the results can hardly get statistical significance and cannot be generalized, this case study has mainly an exploratory purpose, seeking to preliminary test several hypotheses and discover the influences that gamification may have on student performance and motivation.

The purpose of this case study is to evaluate the game mechanics implemented in E-game in terms of improvement of motivation (thereby, reducing undesirable behaviors). Specifically, we investigate whether a gamified learning environment will increase the motivation in the students and reduce the externalization of Gaming the System and improve the performance during the learning process. The experiment provides insight into how many game mechanics enhanced the use of educational systems by increasing the motivation and reducing the undesirable behaviors externalized during its use.

The metrics used to compare the two groups under investigation is the score (points) obtained by the subjects during the use of E-Game and analysis of a questionnaire to measure motivation applied at the end of the task.

3.2.2 Hypothesis Formulation

We formalized the research question (**RQ_1**) into hypothesis so that tests can be carried out:

Null hypothesis, $1H_0$: there is no difference in terms of motivation and reducing undesirable behaviors in a gamified educational system between boys and girls (measured in terms of the score achieved by the questionnaire and the number of 'help') which can be formalized as:

$$1H_0: \mu_{\text{gamified system}} = \mu_{\text{non-gamified system}}$$

Alternative hypothesis, $1H_1$: there is a significant difference in terms of motivation and reducing undesirable behaviors in a gamified educational system between boys and girls (measured in terms of the score achieved by the questionnaire and the number of 'help'):

$$1H_1: \mu_{\text{gamified system}} \neq \mu_{\text{non-gamified system}}$$

The research question **RQ_2** is formalized by the following hypothesis:

Null hypothesis, $2H_0$: there is no difference in terms of performance in a gamified educational system between boys and girls (measured in terms of the score achieved by the number of right questions answered) which can be formalized as:

$$2H_0: \mu_{\text{gamified system}} = \mu_{\text{non-gamified system}}$$

Alternative hypothesis, $2H_1$: there is a significant difference in terms of performance in a gamified educational system between boys and girls (measured in terms of the score achieved by the number of right questions answered):

$$2H_1: \mu_{\text{gamified system}} \neq \mu_{\text{non-gamified system}}$$

3.2.3 Case Study Design

Aimed at verifying our conjecture, we applied a standard design with one factor and two treatments [22]. The main factor (independent variable) of the underlying case study is the game mechanics. The treatments of levels of this factor are two versions of the system E-Game, a gamified and a non-gamified version. In this experiment setup, the main dependent variable (or outcome variable) is the points of the subjects, which is defined by the number of questions they correctly answered using E-Game.

Furthermore, the scores of the motivational questionnaire are used as dependent variables as well to analyze some factors as the subjects interest/enjoyment, perceived competence, perceived choice and pressure/tension during the use of the educational system.

3.2.4 Procedure

The case study design is composed by the following steps: (*i*) personal questionnaire, (*ii*) intervention and (*iii*) motivation questionnaire. In the first step, the subjects were required to fill out a questionnaire with their own information, and it was used as a registration form into the system. The system store and anonymize the identification information (using an arbitrary number for participation identification).

In the second step, the students used the learning environment during one hour for the first time. Although one hour is not sufficient in some environments, in E-Game was enough to measure the goal definition of this work. Initially, the system showed a page explaining how the activity works and the system rules. Next, the students started solving multiple-choice math questions based on material they have studied in school, such as evaluation of algebraic expressions and equations. During their work on the questions, the students using the gamified system could see their ranking within the group and their progress bar in the left sidebar of the interface. . After completing all the questions, the gamified environment shows the final profile page with their scores, badges, quantity of right and wrong questions and the ranking. The non-gamified environment only shows a final page with the quantity of right answers. Both systems ask the student to go to the next step and answer a brief questionnaire about themselves as game players and about their motivation in performing the activity (solving the math problems).

i. Personal Questionnaire

The personal questionnaire contained the results of a general questionnaire. The student population has ages between 12 and 13 years and have economic and educational equality.

ii. Intervention

During the intervention, both groups completed 30 Math questions. For each question answered correctly, the subject won 10 points and to get a tip for a question, the subject had to pay 5 points. For each sequence of 5 questions answered correctly, the subject won a badge. The ranking was updated after each question answered, showing the top 5 students with higher points.

iii. Motivational Questionnaire

The last step of the procedure was the motivational questionnaire, which contained 22 short questions proposed by Deci et al. [9]. The Intrinsic Motivation Inventory (IMI) is a multidimensional measurement device intended to assess participants' subjective experience related to a target activity in laboratory experiments. It has been used in several experiments related to intrinsic motivation and self-regulation [18,19]. The task evaluation questionnaire measures the motivation into 4 categories: interest/enjoyment, perceived competence, perceived choice and pressure/tension.

3.2.5 Analysis of Results

This section presents our experimental findings based on the results described in the previous sections. The analysis is divided into two subsections: (1) results and (2) hypothesis testing.

3.2.5.1 Results:

From Figure 2, it can be seen that:

1) Along both metrics (points collected and number of right answers), there was insignificant difference between the Gamified and the Non-Gamified groups. The Non-Gamified group collected 426.25 points altogether and answered correctly 42.7 questions. The Gamified group collected 423 points and answered correctly 42.6 answers. It is clear that there were very few, if any people asking for help, so no gaming of the system was observed.
2) The female subjects in the non-gamified condition outperformed all other sub-groups obtaining higher scores in both metrics analyzed (number of right answers: 23 and number of points: 228.75). However, the male subjects in the non-gamified condition had the lowest scores among all fours sub-groups (19.7 and 197.5, respectively). The male and the female subjects in the gamified condition had nearly equal scores(210 and 21 vs 213 and 21.6, respectively).
3) The standard deviations for both metrics of the underperforming groups in each condition (boys in the non-gamified condition and girls in the gamified condition) were much higher than the standard deviations of the respective metrics in of the better performing groups. The non-gamified condition, the standard deviation of boys is 63.78 and girls is 26.54. However, the gamified group the numbers is 14.35 for boys and 37.41 for girls.

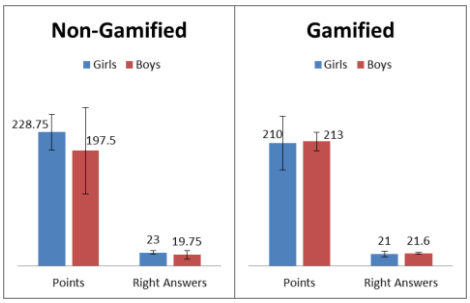

Figure 2 - Data from the intervention.

This suggests that the game mechanics implemented in E-Game had different effects for students with different genders. Considering only the female subjects, the use of game mechanics reduced the learning performance compared with the traditional environment (i.e. with no game mechanics). With male subjects it had the opposite effect; the game mechanics improved their performances.

The gender differences in the impact of the gamification mechanics are more pronounced in of the results of the motivation questionnaire. Figure 3 and Figure 4 show the results of the task evaluation questionnaire, in the aspects of interest/enjoyment, perceived competence, perceived choice and pressure/tension.

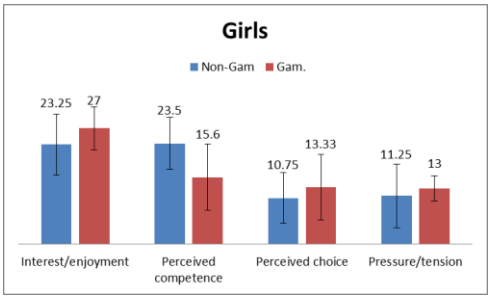

Figure 3 - Results of task evaluation questionnaire for girls

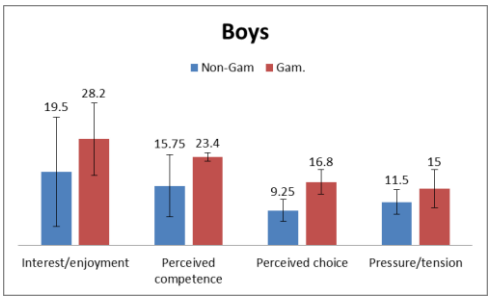

Figure 3 - Results of task evaluation questionnaire for boys

In Figure 3, we observed that girls had a lower perceived competence in a gamified environment compared to a non-gamified environment. Nevertheless, the use of game mechanics offered positive aspects such as interest/enjoyment and perceived choice, since the girls gave higher scores for these factors in the gamified environment. However, they also felt more pressure and tension during the use of the gamified system.

On the other hand, Figure 4 shows that boys had higher scores in all aspects in the gamified environment, including more pressure/tension during the use of the educational system. They had significantly higher perceived competence in the gamified environment than in the non-gamified (the values are nearly reversed to those of the girls). The boys felt they had more choice in the gamified environment than girls, but also more pressure/ tension (15 for boys and 13 for girls).

The big differences between the two environments between the genders were in the areas of perceived competence and interest/enjoyment. Yet overall the non-gamified environment received better scores from the girls, where they felt more interest/enjoyment, more perceived competence and choice, and less pressure/tension than the boys.

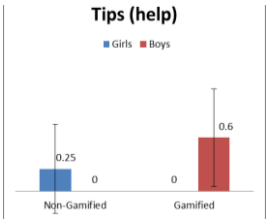

Figure 4 - Results of the tips

We didn't find evidence for Gaming the System during the study. This behavior was identified by Wood et al. [23] as a typical game the system behavior where students rapidly and repeatedly asks for tips (help) to show the correct answer. Figure 5 shows the averages of total counts from the tips (help) that each student asked for. Since there was no reward and no pressure on the subjects to complete the study, there was no reason for them to engage in cheating behaviors. Thus our results cannot answer the question if the gamification mechanics reduced faming behaviors.

3.2.5.2 Hypothesis testing:

Aimed at testing the hypotheses in subsection 3.2.2, we performed a T-test, which is a parametric test used to compare two independent samples [21] and the number of subjects is less than 30. However, the results showed some extra information that wasn't previewed in the hypothesis, but it cannot be ignored, that is the difference between genders. For that reason, each hypothesis will be tested considering this factor.

Analyzing the $1H_0$ in the context of male subjects, we obtained the following results: $t = 5.9744$, 3 degrees of freedom at 5% significance level, p-value = 0.0094. Since p-value is smaller than 0.05 we can refute $1H_0$ for the boys. Therefore, there are evidences to say that for the male subjects the use of game mechanics provide positive results towards motivational standards. Applying the t-test in the context of female gender, we have the following results: $t = 0.0168$, at a 5% significant level, p-value= 0.9877. It turns out we cannot reject $1H_0$ for this group. That is, it is not clear statistically whether the gamified environment is more helpful towards motivation than non-gamified environment.

The $2H_0$ obtained the following results in context of female group: $t = 1.2388$, 1 degree of freedom at 5% significance level, p-value = 0.4323, which is higher than 0.5, meaning no statistically relevance to refute the null hypothesis. The male group also doesn't have statistically significance, with the following values: $t = 0.0664$, at 5% significance level, p-value = 0.9531, which is higher than 0.5. The results mean that there is no difference in terms of performance in a gamified educational system (measured in terms of the score achieved by the number of right questions answered).

Although most of the results are not statistically significant due to the small number of subjects, it is important to run statistical analysis such those presented in this section to identify trends in the data and to provide insights that can help to improve the correct usage of game mechanics in learning environments. We were able to find statistically significant evidence, even with the small number of subjects, that boys are more strongly motivated by gamified environment.

4. CONCLUDING REMARKS

Educational virtual environment is the key for a successful future in the learning aspects with the new generation of students.

However, keeping them motivated throughout the whole learning process is considered one of the major challenges in all forms of learning. One solution for this problem is introducing game mechanics into those environments, making them more interesting, fun and enjoyable. To check the impact of these mechanics in a learning environment, we developed E-Game, a platform that can be used to support learning with and without the use of game mechanics.

The controlled study using a gamified and a non-gamified version of E-Game in a small class showed with statistical significance that game mechanics had a positive motivational effect with the male students. Although the learning performance among the two groups and among genders didn't show statistically significant difference, the numbers of points earned in the gamified system were higher compared to those in the non-gamified system. We did not observe behaviors of Gaming the System in either of the systems. We also found that the game mechanics implemented in E-Game did not have any effect (on motivation and performance) in the female students, which suggests that the studies of gamification in the context of learning should consider gender differences to draw better conclusions about their impact on motivation and learning performance. In future research, we will extend this case study to an experiment and further analyze the gender issue with respect to previous experience with games, in the context of gamified learning environments.

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