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Michael E. Auer
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ICBL International Conference on Interactive Computer Aided Blended Learning

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The Impact of a Gamified E-Learning Environment in Students Attitude: A Case Study

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Abstract. E-learning conditions underpin the teaching and learning procedure and plan to involve students in their insight development process. Notwithstanding, including them during this procedure requires a high level of inspiration. Gamification is one of the methodologies that address this challenge and proposes that on-line situations are going to be a plus from it. On the other hand, Statistics is a field that can be supported by these learning methodologies. These days, with the use of massive data, the information holds a critical worth and to process this information into valuable data empowers the statistics field as a basic subject. This paper expects to feature a replacement point of view over the teaching and learning process offering a gamified e-learning condition to support the statistics field in the class. To research and portray the increases of this system, we refine a contextual investigation strategy to a Probability and Statistics lecture of an undergraduate Engineering course. With a descriptive study, we decide to comprehend the students' attitudes once they face the proposed gamified e-learning condition. The results indicate that were some changes on students' attitude when they use the gamified approach and suggest that we can be on the right track regarding the application of innovative learning formats, especially in the use of ICT.

Keywords: Gamification · E-learning · Attitude towards statistics

1 Introduction

E-learning environments support collaborative activities between teachers and students. This implies plenty of methods to build and oversee instructive exercises [1]. Instructive techniques, built over levels, conjure students in their insight development. In any case, involve them into this process it is still a challenge [2], gamification seems

The original version of this chapter was revised: The author's name has been corrected to "Gonçalves V.". The correction to this chapter is available at https://doi.org/10.1007/978-3-030-67209-6_61

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to be having support for that. Thus, gamification is a technique that may improve e-learning situations. Likewise, it is highlighted to promote the use of game design elements in non-game settings. Consequently, gamification contributes to learners' involvement during their use [3]. Hence, an e-learning proposition with those highlights has risen, as introduced in [4].

e-Class platform emerges in this paper as an instructional e-learning environment to encourage students' participation in a virtual class. Using gamification elements gathered from the literature [5], e-Class was modeled with the property of virtualizing genuine instructing and learning situations as well as to settle on choices about student yields. In this research, we choose the Probability and Statistics scenario in Higher Education since it is hard to be virtualized, as indicated by [6]. Nowadays, the information holds a significant value in society and this conventional study hall course has become a significant apparatus for a few fields, supporting its appropriation.

In this vein, e-Class was applied during a full academic semester. The primary objective is to gather students' behavior data such as participation, motivation, engagement, incentive, and others that allow us to identify the effects of positive or negative discipline behavior in terms of student's attitude. Thus, the SATS instrument (Survey of Attitude Towards Statistics) [7] told us the best way to line up students' attitudes with the subject in question and how these factors allow the adoption of strategies to increase the efficiency of teaching Probability and Statistics [8].

This paper describes the e-Class platform as an e-learning environment which as built over Gamification concepts and provided by a huge Probability and Statistics students' behavior data in Higher Education. The article additionally discusses one of the primary commitments of the environment, considering the adjustment in attitude that can generate in the students associated with this methodology.

2 eClass

The e-Class platform is a user-friendly web-based system hosted at estatistica.ipb.pt. This platform was carefully modelled over three main modules, such as (i) Content Management, (ii) Student Interactions, and (iii) Learning Activities.

On this first module, students access the course content provided by the teachers, such as class notes, plans, study guides, textbooks, and others. The second module provides resources for interaction among students. Thus, students exchange information and experiences in forums and also share documents.

The last module is the core of the gamification approach. Teachers inject questions to students come in to solve them when performing activity tests. In each virtual activity test, students may choose the content and set the range of skill parameter (from easy to difficult). After that, a set of randomly selected questions is provided (Fig. 1). Unlimited trials are allowed, however, limited resources induce students to explore different contents and parameters. Additionally, this approach uses a 'sandbox-style' game, signing there is no linear narrative structure [9]. At the end of the virtual activity test, instant feedback is provided with the performance results. Here, gamification aims to involve students in such activities and guide them in an appropriate pedagogical sequence.

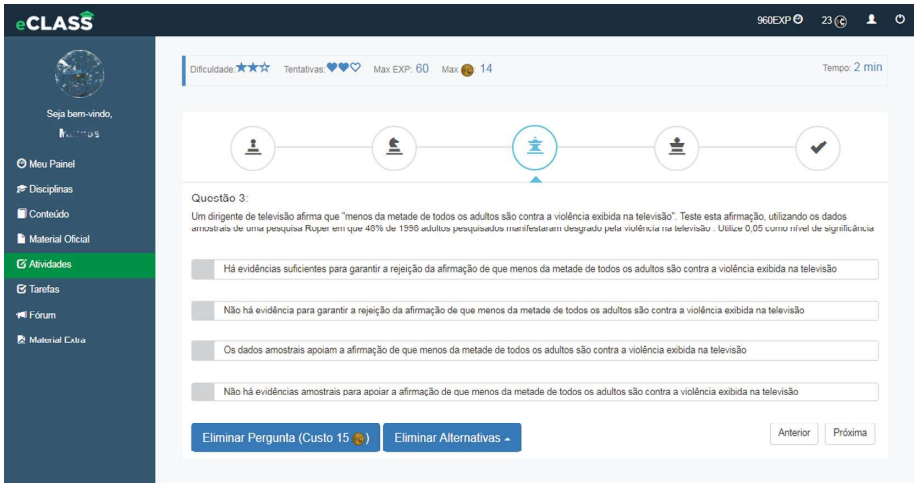


Fig. 1. Learning Activities module during use

In the eClass, the feedback is not limited to students. On the teachers' side, each students action are reported like forums, content, interactions and activity tests. Teachers access all activity test attempts and may identify issues and routes chosen by each student.

This feature allows professors to make decisions and act based on these reports. They may use this tool to provide formative or summative assessments in runtime. Ultimately, the e-Class also suggests a final score based on students' performance.

2.1 A Gamified Structure

Gamification offers mechanisms to reach a game-like approach. In e-Class, we implemented Experience Points (EXP), Badges, and Virtual Coins (eCoins). All these three engines have the role of encouraging users during virtual class. There are also other elements to virtualize the real student environment, such as timeline, progress bar, limited resources, time restrictions, exchanges, feedback, and others. However, the elements were addressed mainly to the Learning Activities module, this means students are guided during the set of parameter choices that implies in rewards.

The Experience Points (EXP) engine controls numerical values, like a score, that each student collects through the EXPi sum function. Mainly on the Learning Activities module, EXPi is earned when an activity test is performed, Eq. (1).

$$\begin{aligned} j = 1 \quad &\rightarrow \quad EXP_i = performance \\ j = 2 \quad &\rightarrow \quad EXP_i = performance \times 0.6 \\ j = 3 \quad &\rightarrow \quad EXP_i = performance \times 0.3 \\ j \geq 4 \quad &\rightarrow \quad EXP_i = performance \times 0.1 \end{aligned} \tag{1}$$

Where j is the number of attempts within a parameter set and *performance* is the score (0–100) result of the activity test. Here, the EXPi value decreases when the same

parameters are chosen. In general, the EXP is a broad measure of success on assessments, at the same time guide the students on the parameters choices. In addition, some authors suggest that students are motivated when use this element and this can increase the users' involvement [10, 11].

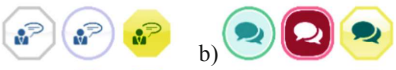
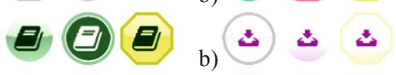
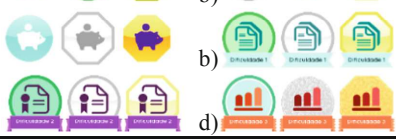
Virtual Coins also follow the EXP principle but changes the earnings according to the chosen difficulty, Eq. (2).

$$eCoin = (EXPi/10) \times dif \tag{2}$$

Where, *dif* is the difficulty parameter chosen by the student (1–3). The *eCoin* is a virtual asset that can be exchanged in easiness on future activity tests. Although this element is underreported in the literature it is useful when students see it as a reward and progress measure [12].

On the other hand, Badges are well explored in gamified environments and usually accredit attitude or behavior [13]. Here, they were designed to recognize and accredit experiences and actions in each module (Table 1).

Table 1. Badges

Module	Actions	Layout
Access	a) Loggin in frequently	
Forum	a) Publish b) Generate comments	
Extra Content	a) Publish b) Generate downloads	
Activity	a) Perform activity without trades b) Explore difficulty 1 activities c) Explore difficulty 2 activities d) Explore difficulty 3 activities	

Each rightful action results in a badge and more repetition improves this badge. This implies smaller goals within each action. High-level badges represent higher value with different layout and colors replacing previous ones. Badges are shown to students as soon as they earn them, then they are shown in the profile crediting their experiences and actions [14].

3 Attitude Towards Statistics

Attitude is characterized as the individual's predisposition while responding favorable or unfavorable to objects, circumstances, facts, individuals, or propositions [15]. Attitude is not behavior nor motivation, although it is characteristically identified with them.

Some authors recommend that this inclination is conceivable to be altered, given the way that it endures impacts and changes with circumstances or environment [16, 17].

Inside instructing and learning environments, the students' attitude is mainly expressed through feelings of engagement, participation, motivation, and others. These feelings are driven to the course or class content. The comprehension of these issues permits us to adopt methodologies to impact positive attitudes and increase efficiency in the instructing and learning conditions [16].

To gather the students' attitudes information inside the Statistics field, we have chosen the Survey of Attitudes Toward Statistics (SATS). This because of the most grounded confirmation about form authenticity and inside consistency [7]. This review grants us to assess students' replies going up against a situation where they need to utilize the learned statistical content [18].

The SATS, introduced in Table 2, is composed of 28 Likert-type scale items that assess each of the four dimensions of students' viewpoints. Those dimensions cover attitudes, such as (a) Affect – students' positive and negative feelings concerning statistics, (b) Cognitive Competence - attitudes about intellectual knowledge and skills when applied to statistics, (c) Value - attitudes about the usefulness, relevance, and worth of statistics in personal and professional life, and (d) Difficulty - attitudes about the difficulty of statistics as a subject [7].

Table 2. SATS

Affect	Value
1. I will like statistics. 2.* I will feel insecure when I have to do statistics problems. 11.* I will get frustrated going over statistics tests in class. 14.* I will be under stress during statistics classes. 15. I will enjoy taking statistics courses. 21.* I am scared by statistics.	5. Statistics is worthless. 7. Statistics should be a required part of my professional training. 8.* Statistical skills will make me more employable. 10.* Statistics is not useful to the typical professional. 12.* Statistical thinking is not applicable in my life outside my job. 13. I use statistics in my everyday life. 16.* Statistics conclusions are rarely presented in everyday life. 19.* I will have no application for statistics in my profession. 25.* Statistics is irrelevant in my life.
Cognitive Competence	**Difficulty**
3.* I will have trouble understanding statistics because of how I think. 9.* I will have no idea of what's going on in statistics. 20.* I will make a lot of math errors in statistics. 23. I can learn statistics. 24. I will understand statistics equations. 27.* I will find it difficult to understand statistics concepts.	4. Statistics formulas are easy to understand. 6.* Statistics is a complicated subject. 17. Statistics is a subject quickly learned by most people. 18.* Learning statistics requires a great deal of discipline. 22.* Statistics involves massive computations. 26.* Statistics is highly technical. 28.* Most people have to learn a new way of thinking to do statistics

This scale ranges from 1 ("Strongly disagree") to 7 ("Strongly agree"), yet 4 ("Neither disagree nor agree") is the center term. All reaches, with higher evaluations, show a progressively uplifting order. The items comprising each attitude dimension are averaged to yield the score for that dimension and some specific items (*) have reversed the responses to the negatively worded items.

In the end, it is possible to evaluate students' responses when confronting a circumstance where they should utilize the learned statistical content. In such cases, the attitude can turn into a facilitator or a snag to students learning. Thus, it is important to understand these issues to promote positive attitudes in students [16–18].

In [18] several similar studies with SATS are compared and the author verifies that, normally, there is a direction to reduce attitude values during the course, since the students become aware of the discipline in time. In the Statistics context, [19] demonstrate unfavorable attitudes in the difficulty dimension, however a general reduction in attitude indexes in the posttest. The general reduction trend was found even in the scale validation [7]. Subsequently, the same author reports that in most favorable results, a new method or innovative learning format was applied [18].

4 Method

To research and portray the increases of this system, we refine a contextual investigation strategy to a Probability and Statistics lecture of an undergraduate Engineering course. A descriptive study was chosen to understand the students' attitudes since they face the proposed gamified e-learning condition.

The study was approved by the Research Ethics Committee (CEP - UTFPR) under process number 00976418.6.0000.5547, being both ethically and methodologically adequate regarding the researches with human beings.

The students of Probability and Statistics were participants to this research during a semester of an engineering course at the Federal University of Technology - Paraná (UTFPR), Brazil. From the beginning of the semester, the students have logged to the system, receiving initially instructions about how to use the modules and concerning its general functioning.

The statistics analysis was performed using the SATS instrument described before (Table 2). All positive and negative statements regarded in Statistics about the four dimensions of the attitude were made. When collecting students' attitudes, [7] recommends two application moments, the pretest and posttest. So as to grasp the attitude differentiation when the e-learning is applied, as suggested by Schau [7], the pretest was applied at the first three weeks of the semester and the posttest one week before the final exams.

There were 45 students responding the questionnaire, however 37 students answered both the pretest and the posttest. Here, only the 37 students who participated in both moments were considered for analysis. To proceed with the statistical analysis, first the internal consistency of the scale was measured using Cronbach's alpha (α_c). Reduced α_c values may suggest inadequate interpretations of the questions, impairing a dimension consistency. Table 3 shows the collected values.

Table 3. Cronbach Alpha

Attitude dimensions	Items	α_c pretest	α_c posttest	α_c suggested
Affect	6	0.81	0.70	0.80 a 0.89
Cognitive Competence	6	0.81	0.75	0.77 a 0.88
Value	9	0.62	0.77	0.74 a 0.90
Difficulty	7	0.42	0.67	0.64 a 0.81

To adjust the dimension α_c to suit Schau's recommendation, or at least reach the αc recommended for Likert scale questionnaires ($\alpha_c > 0.7$), it is possible to remove some items that most harms the results. Here, items that would significantly increase reliability were identified and removed: Statement 15 and 26. Table 4 shows the α_c final values.

Table 4. Adjusted Cronbach Alpha

Attitude dimensions	Items	α_c pretest	α_c posttest	α_c suggested
Affect	5	0.83	0.75	0.80 a 0.89
Cognitive Competence	6	0.81	0.75	0.77 a 0.88
Value	9	0.62	0.77	0.74 a 0.90
Difficulty	6	0.61	0.69	0.64 a 0.81

Finally, after the items removal, we reach an acceptable α_c value to Likert-type questionnaires to the majority of dimensions. Further removals was not favoring the internal consistency of the scale. Then, statistical analysis was performed.

5 Results

Table 5 presents the descriptive statistics of the values collected from the pretest and posttest. Here, each dimension presents a value between 1 and 7, meaning higher the value, more positive the students' attitude towards this dimension.

Table 5. Descriptive Statistics of Attitude Towards Statistics

	Affect		Cognitive Competence		Value		Difficulty	
	pre	post	pre	post	pre	post	pre	post
Average (M)	4.71	4.78	4.91	4.88	6.21	6.07	3.71	4.02
1º Quartile	3.60	4.00	4.00	4.17	5.89	5.67	3.17	3.33
Median (MD)	5.00	4.80	5.17	4.83	6.11	6.22	3.67	4.00
3º Quartile	5.40	6.00	5.67	5.83	6.67	6.67	4.33	4.33
Standard Deviation (*s*)	1.31	1.15	1.04	1.00	0.55	0.67	0.87	0.97
Coefficient of Variation (CV)	0.28	0.24	0.21	0.21	0.09	0.11	0.24	0.24

A boxplot graph was built to explain another perspective, including the dimensions and intervals (quartiles), Fig. 2.

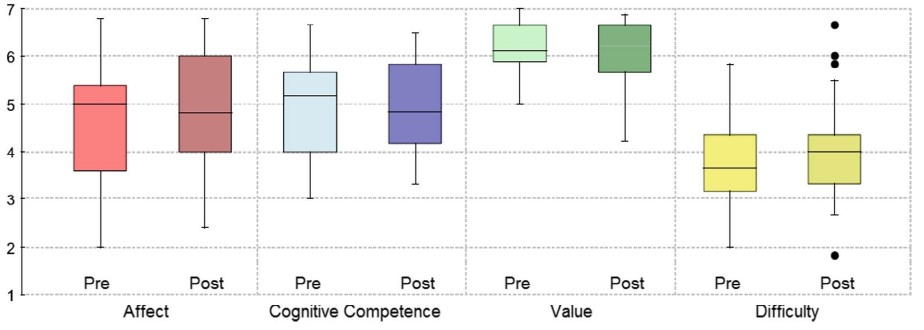


Fig. 2. Boxplot of Attitudes Towards Statistics

The statistical results bring some significant contemplations concerning the connection between the attitude measurements and the eClass environment.

Initially, the Affect dimension showed attitudes with a slight negative trend, especially in the pretest. In the posttest, the boxplot suggests an apparent improvement in the indices, with less variation. To measure this difference, a Hypothesis Test was performed, using the t-test statistic with 95% confidence level ($\alpha = 0.05$).

The Hypothesis Test shows that there were no significant difference for this dimension between the pre and the posttest ($p = 0.72$). Still, two statements in this dimension proven a significant change: Statement 2 ($p = 0.04$) and 14 ($p = 0.02$). Statement 2 showed the lowest average on pretest ($M_{i2\text{-}pre} = 3.9$), proving that students felt insecure when studying statistics. In the posttest, there is a statistically significative increase ($M_{i2\text{-}pos} = 4.5$), meaning that students did not feel so insecure afterwards. Statement 14 also shows a significant increase in the posttest ($M_{i14\text{-}pre} = 5.2$ to $M_{i14\text{-}pos} = 5.9$), demonstrating that students were not so tense with the discipline afterwards.

In the Cognitive Competence dimension, most students scored average values close to 5. The Hypothesis Test shows that, with 95% confidence, there was no significant difference from the pretest to the posttest ($p = 0.87$). Besides, inside this dimension no item showed a significant difference, even so, in the item 20 presented a lower average in both tests ($M_{i20\text{-}pre} = 4.1$ and $M_{i20\text{-}pos} = 3.8$), stating that they make math errors when doing the statistical calculations.

In the Value dimension, students showed the best attitudes ($M_{VALUE\text{-}pre} = 6.2$ and $M_{VALUE\text{-}pos} = 6.1$) and low variation ($CV_{VALUE\text{-}pre} = 0.09$ and $CV_{VALUE\text{-}pos} = 0.11$). It is also worth to noted that the posttest shows attitudes with a slight reduction when compared to the pretest. The Hypothesis Test demonstrated, with 95% confidence, that there was no significant difference in this dimension ($p = 0.08$). Several items of this dimension showed the same values in the posttest (items 5, 7, 8 and 25). Items 12, 13, 16 and 19 showed a small reduction, with item 13 having the lowest average in both tests ($M_{i13\text{-}pre} = 5.0$ and $M_{i13\text{-}pos} = 4.7$). It is worth mentioning that the values of

attitude towards this dimension are still high, and students continue to have positive attitudes towards the value of statistics.

The Difficulty dimension had the lowest rates of attitudes in the pretest. However, the posttest shows an increase. The Hypothesis Test shows that, with 95% confidence, there is a significant difference in this dimension ($p = 0.03$).

Items 18 and 17 in the pretest showed the lowest averages ($M_{i18\text{-}pre} = 2.9$ and $M_{i17\text{-}pre} = 3.3$), where they considered that to learn statistics it is necessary to have a great deal of discipline and it is hard to be learned by most of people. In the posttest, all items showed improvement and items 4 and 6 reached a higher average ($M_{i4\text{-}pos} = 4.9$ and $M_{i6\text{-}pos} = 4.6$). This suggests that, in the posttest, the students found it easier to understand the statistical formulas and that the subject later presented itself as less complicated.

6 Conclusions

The results analysis collected through SATS with the eClass bring some important considerations especially in Attitude dimension.

Initially, the feeling of affection, during the affect dimension was raised from pre to posttest, increasing the average, and reducing the standard deviation. In any case, a Hypothesis Test showed no significant difference between pre and posttest, only just two items that accomplished noteworthy improvement and show students losing their fear of the discipline. By allowing constant connection with the discipline, one of the main goals of eClass planning, students end up losing the fear of the discipline and felt more secure.

In the Cognitive Competence dimension, it is hard to establish a causal relationship, as there was no significant difference. The interesting point here is the student's difficulty reported in mathematical calculations and statistical concepts. This is a signal to the eClass and the discipline, they must pay attention at the students' difficulty with such issues and work with this.

In the Value dimension, there were higher attitudes on both tests and no significative distinction. The items related to the statistics usage outside the academic environment present reduction in posttest. This suggests that, after advancing the specific contents, students became more aware of the discipline content, rethink their responses and reduce the value of the statistic regarding workplace and everyday life.

In the Difficulty dimension, students initially presented a negative perception about it. The Hypothesis Tests show a significant difference on the posttest. This improvement exhibit that students change their opinion on the discipline difficulty, showing that now it is easier to understand statistics formula and believing that it is possible to learn this subject. As noted in the Affect dimension, the use of eClass may have facilitated the process of understanding statistics and changed students' perception of their difficulty.

The results expressed in this study comes to reinforce Schau's theoretical consideration, suggesting that a innovative teaching environment, apart from traditional ones, involves the student in a new learning format, favoring the attitude.

When considering that e-Class usage may favored the students' attitudes, it is possible to consider that several factors may also be positively influenced, especially in Probability and Statistics learning. Although it is out this work bounds, there are some literature studies that draw this comparison and states that even academic performance can be favored by attitude [16, 17, 19].

There are obviously changes in the eClass, or even in the discipline structure, which can further improve attitude rates. Even so, what we have so far is a strong evidence that we can be on the right path regarding the innovative learning formats.

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