A Quantitative Analysis of the Most Relevant Gamification Elements in an Online Learning Environment

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ABSTRACT

In the last decade, many researchers have studied the use of game elements in education. The term "gamification" refers to the application of elements used in the development of video games, such as mechanics and dynamics in other contexts unrelated to games, to generate more enjoyable and positive attitudes from the students. The gamification process involves using several elements present in video games, like: points, levels, rankings, rewards (badges / achievements) and missions. In this study, we assess whether or not, gamification elements can help and motivate students enrolled in a gamified ontology-based adaptive online learning environment called MeuTutor. In this context, we followed the Pedagogical Recommendation Process to discover which gamification elements were relevant to promote learning, in order to recommend improvements to the environment. To do that, this study shows a quantitative analysis (correlation analysis) of the gamification elements from MeuTutor.

Keywords

Gamification. Learning analytics. Education. Ontology-Based Adaptative Learning Environment

1. INTRODUCTION

In the last decade, many researchers have studied the use of game elements in education. As suggested by [7], the term "gamification" refers to the application of elements used in the development of video games, in contexts that are unrelated to games.

Assessing a student is equivalent to give them a score; their grades are published as a ranking (leaderboard) of students from the same class; the students "level-up" when they pass a grade. In these cases, game elements are used in an ontology-based online learning environment [7] to represent known educational procedures. According to [13], gamification can generate motivating effects on students, as well as more enjoyable and positive attitudes in the classroom.

According to [16], the gamification process of a system can involve the use of several elements from games. Some of the most common elements are: points, levels, rankings, rewards (badges/achievements) and missions. Such elements may promote changes in student's behavior, for example in the case of rankings, where students compare their progress with others, creating a sense of competition within the learning environment.

Besides that, in the recent years, there is an increase in the development and use of ontologies with the objective of creating more intelligent and effective applications. This increase is due to the potential of ontologies in providing semantics for the data consumed by machines, allowing them to reason on these data. Providing sophisticated tools that improve the development of applications based on RDF and OWL can further accelerate the adoption of the SemanticWeb [10]. Adaptable learning environments can benefits from the use of ontologies, given this potential for reasoning on the data.

Considering this context, the main purpose of this article is to collect usage data answer in order to answer question about gamification in education: What elements of gamification are the most relevant to promote learning?

This article makes a quantitative analysis using a statistical method, to evaluate which gamification elements (most

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commonly available within an ontology-based online learning environments) are the most relevant to promote learning.

The paper is organized as follows: section 2 presents the background, (A) Gamification theory, where we explain the concept and (B) MeuTutor learning environment and its main features; Section 3 presents the related work; Section 4 describes the method used; Section 5 presents the results and discussion; Section 6 presents the conclusion and the limitations of this work.

2. BACKGROUND

This section describes the basis for the design of this work. In subsection A, we describe the gamification technique, its concepts and characteristics. In subsection B, we describe the main features and characteristics of MeuTutor, the learning environment used in this study.

2.1 Gamification

Education is always in search of innovation. Some of them focus on stimulating student's interest and extending the educational tools available for teachers. One of these tools is the gamification technique, which is increasingly being used in online learning environments. Gamification is the use of game elements, game-design and game-mechanics, in non-game contexts [16].

Gamification has been defined as a process of enhancing services with (motivational) affordances in order to invoke gameful experiences and further behavioral outcomes [13]. Gamification makes use of the elements present in electronic games, such as rewards, feedback, rankings and exchanges. Their application in education can motivate students to perform certain tasks or competitions to achieve particular objectives. Gamification tasks aim to increase user engagement, encourage and promote greater interaction among students, allowing a harmonious development of the class as a whole, with targets/goals being achieved collectively and not only through individual scores [4] [8] [9].

2.2 Ontologies

According to [10], ontology, in the computer science, is a set of concepts and its relations used to model how people understand (or interpret) a certain domain (real-world entities), allowing the representation of such understanding in a formal way that humans and machines can comprehend.

In recent years, ontologies have gathered significant attention by the computer scientific community, once it aims to solve one of the biggest problems that arises when using machines to reason on information generated by human agents. They are considered the most appropriate way to facilitate the interoperability between heterogeneous systems involved in a domain of common interest [11] [12].

Ontologies are applied both as a basis for the Semantic Web [2] and as a tool to solve problems in several areas of computing research and industry. For instance, there are approaches for building educational systems using ontologies to represent knowledge about students and educational resources and pedagogical strategies [2]. MeuTutor is one of these systems.

2.3 MeuTutor

MeuTutor is an intelligent web educational environment that seeks to accomplish the monitoring of students learning in a personalized way, focusing on the teaching quality and the student's performance [15]. The environment provides support to high school students with specific content in preparation for the ENEM[1], offering 10 (ten) subjects (domains). For each domain, a tree-like structure (cognitive tree) represents the knowledge required for the ENEM exam. The system also provides reports through the student's profile, showing the general statistics, including: missions, levels, points, badges, completed domains, completed curricula, videos watched, problems solved and test answered.

Through problem solving, for each subject (domain) available in the platform, students can acquire new knowledge, check and practice it. Questions are offered to students through direct interaction with a curriculum (topic), through mock tests students can personalize, and through missions and badges where students need to accomplish a set of tasks, and problem-solving may be one of these tasks. If they succeed in correct answering a certain number of questions, for a certain curriculum (or related to it), that indicates they learned the related curriculum, which allows them to move on to another one. If not, the learning environment recommends videos with specific content to help the students. To assess the students' level of knowledge, MeuTutor offers a tool to create customizable tests, where students can select which topics (curriculum) of a particular subject (domain) they wish to be tested. It is also possible to generate mock tests that simulate a real ENEM exam. This whole concept of personalization of learning offered by MeuTutor comes from the use of techniques from the field of Intelligent Tutoring Systems (ITS), which are educational systems that make use of features of artificial intelligence to customize learning according to the needs of each student [15].

The mathematics domain, hosted by MeuTutor, is available online and free of charge for all students from Brazil who wish to prepare for the ENEM. At the time of data collection for this research, the MeuTutor possessed approximately 9000 users registered with free accounts, from all states in Brazil.

MeuTutor uses gamification to engage, encourage, motivate and promote greater interaction among students. It also uses ontology to providing semantics for the data MeuTutor produces and consumes, with the intention of allowing it to reason on these data to improve adptation.

3. RELATED WORK

Many studies address the use of gamification elements in the processes of teaching and learning in order to motivate and engage students in the pursuit of learning. According to [6], there is a growing interest in gamification, its applications and implications. The authors performed a systematic study and initially obtained 357 studies on gamification. Among these studies, 48 were related to education and only 26 met the criteria for inclusion in the work. As a result, a map of the research area was developed and topics most (and least) explored were identified indicating that the majority of the studies focused on investigating how gamification can be used to motivate students, improve their skills and maximize learning.

According to [3], the engagement of users in collaborative systems is essential for users to achieve their goals more easily. The authors present a theoretical foundation for collabo-

[1]The National Secondary Education Examination (ENEM). For more detail, access: http://portal.inep.gov.br/enem

rative systems, gamification, gaming elements and a comparative analysis between techniques and systems. Finally, the authors conclude that the techniques used by most systems were the points system, the use of badges and challenges. The results suggest that the use of gamification is a positive factor in engagement and user experience.

However, [1] presents an analysis of data from a pilot experiment on the users' perception of the elements of gamification in the mobile social network named Foursquare. The authors present a theoretical framework about social networking, gamification and the Foursquare application, profile of participants, data analysis, discussions about the experiment and concluded that not all elements of games applied on Foursquare had good acceptance showing that gamification is most effective when combined with other forms of motivation, such as sharing information on their social networks.

For [17] making an analysis of language teaching in virtual environments gamification highlights three elements of gamification: points, badges and rankings as relevant to keep students involved in learning activities. The author says that in gamification, the mechanics of activities are inspired by some elements of games such as levels, achievement badges and medals, point systems and time constraints.

In this scenario [15] defines that badges should reward students for accomplishing certain actions in the system, such as, correctly answering 10 questions in a row. The levels represent the evolution of the knowledge of students in each subject (domain). Points are the most basic game element in gamified environments; the majority of students' interactions with these systems are rewarded with points. Finally, the rankings and missions allow, respectively, the students to compete with friends and maximize its evolution in the system.

4. METHOD

The aim of this research is to identify the most relevant gamification elements in a gamified online learning environment. For that purpose, we analyzed usage data, containing the students' interactions with the gamification elements offered by a learning environment called MeuTutor, from May, 2014 until November, 2014.

In summary, students were divided by their gamification level[2]. There were only a few students in levels above 4, so we opted to study the interactions of students' from level 1 to 4. We randomly choose an equal number of students per studied level, and for each student, in each of the gamification levels studied, we calculated their performance (Percentage of Problems Solved Correctly - PPSC). We detail these steps, in the following paragraphs.

The first step was to identify which gamification elements were offered by MeuTutor. That was achieved by manually exploring [18] the learning environment. We identified the following gamification elements: missions, points, trophies and ranking.

We, then, noticed that it was necessary to measure the students' performance (learning), so that we could identify

[2]MeuTutor grants students points for interacting with the educational resources available. After earning a certain amount of points, students level-up (from 1 to 10) for each domain offered by MeuTutor. This represents the students' gamification level.

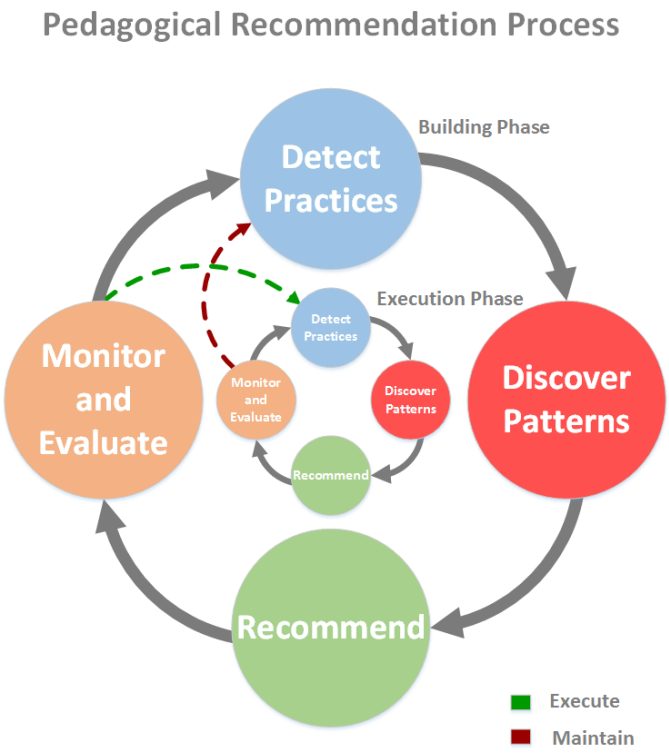

Figure 1: The Pedagogical Recommendation Process.

the relationship between learning and the students' interaction with the gamification elements. For that purpose, we considered the ratio between the Problems Solved Correctly and Total Amount of Problems Solved (which we named Percentage of Problems Solved Correctly, PPSC), an indication of the students' performance.

Next, we grouped students by level (gamification level, calculated by MeuTutor) and the PPSC ratio created for each student.

We then used Pearson's Correlation Coefficient to check the relationship between the students' groups and the available gamification elements.

In this study, we present an analysis of gamification elements based on the Pedagogical Recommendation Processe [14]. It is a cyclic process with two phases (building and executing), and four steps in each. It uses educational data to detect pedagogical issues, discover patterns associated to them, create recommendations to address these issues and, finally, monitor and evaluate if the recommendation was effective.

Initially, data was collected from a total of 3989 students. After that, a filter was applied to remove students that were enrolled, but have not accessed the environment, yet. It resulted in 3732 students. In a third stage, a second filter was applied to remove students who were enrolled, but did not solve any problem, totaling 837 students. Finally, we applied a filter to keep only the students who were in levels 1, 2, 3 and 4, which resulted in 833 students for the analysis in this paper.

In order to indentify the importance of each gamification element studied, we checked their relatioship with the stu-

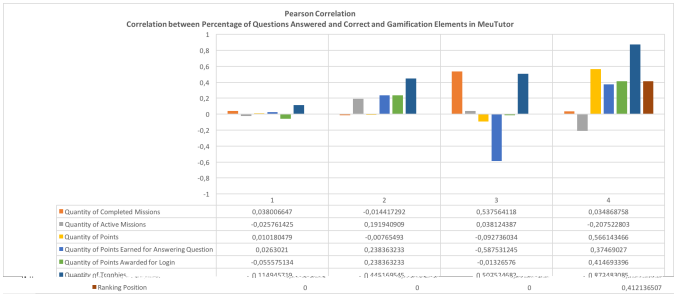

Figure 2: Correlation (Pearson) between Percentage of Problems Solved Correctly and gamification elements in MeuTutor.

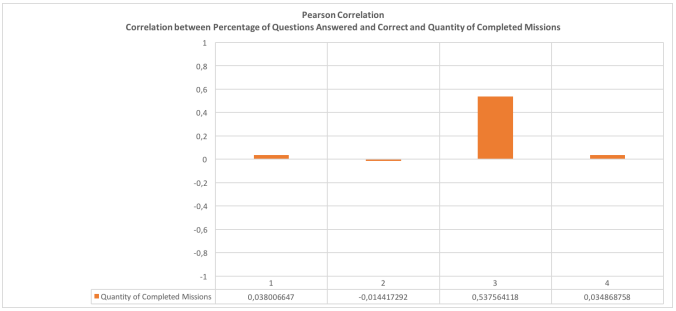

Figure 3: Correlation (Pearson) between Percentages of Problems Solved Correctly and Number of Completed Missions.

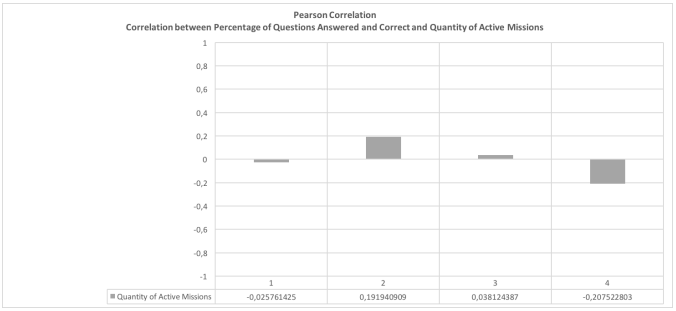

Figure 4: Correlation (Pearson) between Percentages of Problems Solved Correctly and Number of Active Missions.

dents performance (based on the metric PPSC). For that, we used Pearson's Correlation Coefficient (r), which is a measure of linear association between variables, according to the following mathematical expression:

$$(1)\ r = \frac{\Sigma(x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\Sigma(x_i - \bar{x})^2 \Sigma(y_i - \bar{y})^2}}$$

According to [5], the Pearson's Correlation Coefficient (r) varies from -1 to 1. The sign indicates positive or negative direction of the relationship and the value suggests the strength of the relationship between variables. [5] defines the coefficient as a statistic measure used to calculate the intensity or degree of relationship between random variables.

5. RESULTS AND DISCUSSION

This section presents the details of the study and the information collected during the process of data analysis. The study was conducted with a sample of 833 active students in MeuTutor, whose interactions were analyzed based on four variables: (1) Percentage of Problems Solved Correctly; (2) Number of completed missions; (3) Number of points; (4) Number of points earned for answering questions.

Grouping the 833 students according to their level resulted in the following: level 1: 783 students, level 2: 19 students, level 3: 18 students, level 4: 13 students.

The following graphs show the correlation between the gamification elements and the students' level. We also used trend lines (a graphical representation of trends in data series) to help us identify a possible relationship between the studied variables.

Figure 2 presents the correlation between Percentages of Problems Solved Correctly and the interaction with the gamification elements available in MeuTutor.

Figure 3 presents the correlation between Percentages of Problems Solved Correctly and Number of Completed Missions in MeuTutor. MeuTutor recommends missions to students who keep accessing the environment. There are easy, moderate and hard missions, which are recommended based on the students' level and the history of completed missions. Once students accept it, its status is changed to "Active". However, missions are costly, demanding some time and effort to be completed (some of them require successfully completing two or more actions). As suggested in Figure 4, students start interacting with them in level 2 (accepting the suggested missions), and complete them when they are in level 3, but for the reasons mentioned (time and effort), they gradually loose their interest (Figure 4), and the missions start not to play an important role in their performance.

Figure 4 presents the correlation between the Percentages of Problems Solved Correctly and the Number of Active Missions in MeuTutor. In this graph, as mentioned above, students start interacting with them in level 2 (accepting the suggested missions), which is weakly related to their performance. However, as they experiment the missions dynamics, and as more moderate and hard missions are offered as students level-up, just a few students keep accepting new missions (making them "Active" missions), and in level 4, completing missions (weakly) disturbs the students performance.

Figure 5 presents the correlation between the Percentages of Problems Solved Correctly and the Number of Points. In this graph, we can notice that students in level 2 and level 3 display an inverse relationship. This may be due to the fact that most students, in the initial levels (1, 2 and 3) focus on activities that grant them points, rather than make them learn. This behavior, considerably, changes in level 4, where we believe students are more familiar with the environment, and start shifting their focus from the gamification elements.

Figure 6 presents the correlation between the Percentages of Problems Solved Correctly and the Number of Points Earned for Answering Questions. In this graph, we can notice that students in level 3 display an inverse relationship. This may be due to the fact that most students, in level 3, were interacting with the missions they have activated during level 2 (Figures 3 and 4). Missions require that stu-

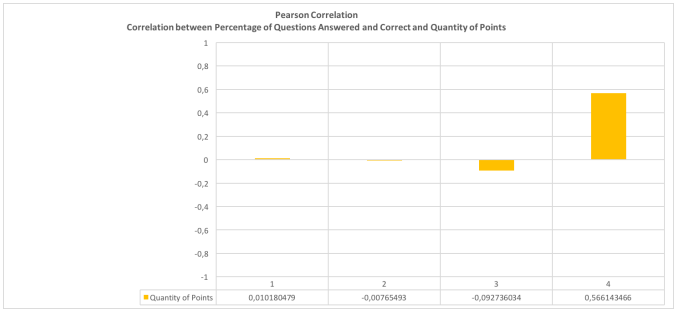

Figure 5: Correlation (Pearson) between Percentages of Problems Solved Correctly and Number of Points.

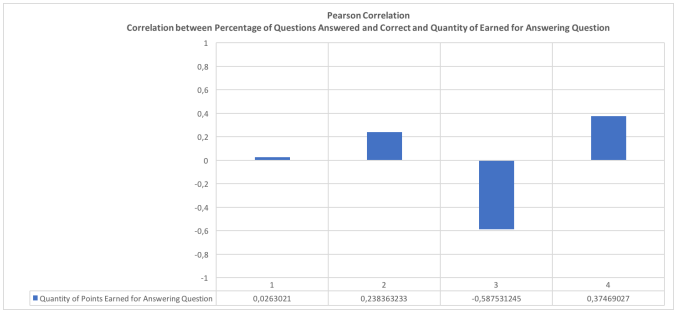

Figure 6: Correlation (Pearson) between Percentage of Problems Solved Correctly and Number of Points Earned for Answering Question.

dents complete some tasks, which may deviate them from answering questions (problem-solving), thus reducing their performance (considering the PPSC).

Figure 7 presents the correlation between the Percentages of Problems Solved Correctly and the Number of Points for Logging in MeuTutor. Comparing Figures 6 and 7, we notice that when students were more engaged answering questions, they made more access (levels 2 and 4). However, students in level 1 tend to explore the resources available in the environment, not particularly focusing on those that promote learning. Students in level 3, as mentioned before, spent much time completing missions, which did not contribute to their learning (considering the PPSC).

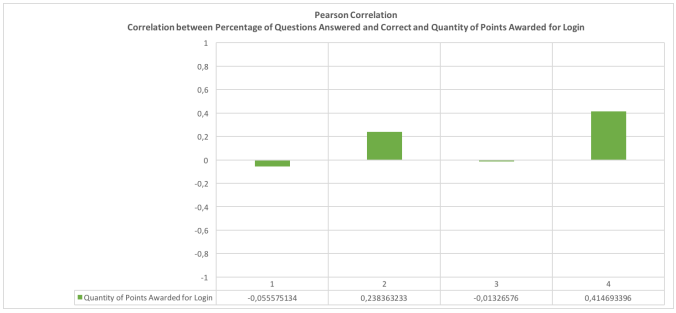

Figure 7: Correlation (Pearson) between Percentages of Problems Solved Correctly and Number of Points for Logging in.

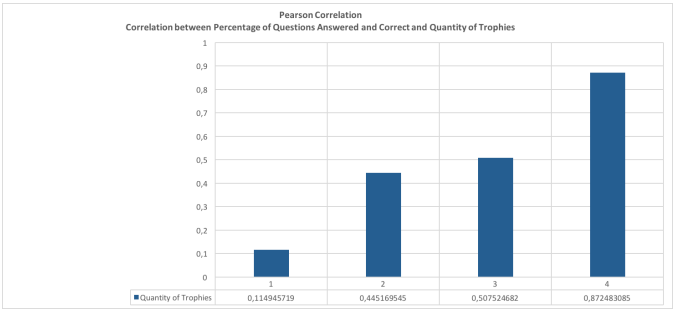

Figure 8: Correlation (Pearson) between Percentages of Problems Solved Correctly and Number of Trophies.

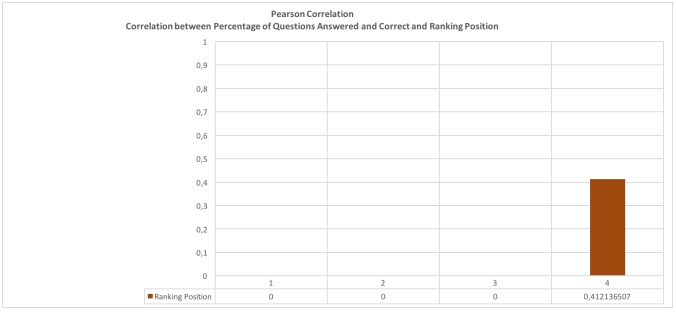

Figure 9: Correlation (Pearson) between Percentages of Problems Solved Correctly and Ranking Position.

Figure 8 presents the correlation between the Percentages of Problems Solved Correctly and the Number of trophies. In this graph, we can notice an increasing correlation between the PPSC (performance measure) and the amount of trophies earned by the students. Levels 3 and 4 display the strongest correlations.

Figure 9 presents the correlation between the Percentages of Problems Solved Correctly and the students' position in the Ranking (leaderboard). In this graph, we can notice that there is no correlation for students in levels 1, 2 and 3.

Answering the question addressed in this study: Which gamification elements were most relevant to promete learning? We noticed that different gamification elements were differently relevant based on the students' levels.

6. CONCLUSION

As we presented, gamification techniques are increasingly being used, in the education field, to motivate and engage students. However, we did not know their relationship and effect magnitude with learning. In this work, we presented the method we used in order to (1) detect practices regarding this relationship, (2) discover its patterns and (3) recommend changes in the process. In our approach, we collected data on the students interactions with gamification elements available in an ontology-based online learning environment. We grouped students according to their (gamification) level (levels 1, 2, 3 and 4), and for each group we created a ratio to represent how well students were performing in MeuTutor. In order to identify how much these gamification elements affected learning, for each one of them we calculated

its Pearson's Correlation Coefficient with the performance ration.

The results and analysis in the previous section, shows that most students in the initial levels (1, 2 and 3), have more diverse interactions, i.e., they interact with different gamification elements, while more advanced students (level 4), focus on those interactions that significantly affect their performance. One situation shown by the data is that students in levels 1, 2 and 3 tend to interact with a gamification element named Mission. In MeuTutor, completing a mission is a time consuming task that diverts students' attention from solving problems (a task that is considerably related to the students performance).

These findings generated some recommendations to improve the learning environment, and provide guidance to students, focusing on improving their performance and interactions (more meaningful/productive interactions). These recommendations were presented to MeuTutor team. Unfortunately, we could not monitor whether these recommendations generated actual changes in MeuTutor, and we could not evaluate whether these changes improved students performance.

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