An Evaluation of the GamAnalytics Tool: Is the Gamification Analytics Model Ready for Teachers?

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Abstract. *In order to improve students' learning outcomes, researchers and practitioners have increasingly applied gamification in technology-enhanced learning environments. However, some studies in the literature have reported unexpected negative results with that. To avoid these unexpected outcomes in gamified learning systems, we proposed the "gamification analytics model for teachers" in a previous study. This model allows teachers to monitor and adapt the gamification design in the run-time of the teaching-learning process. In this paper, we present the results obtained in an empirical study to assess teachers' perception and acceptance regarding the GamAnalytics tool, a tool developed based on our proposed model that allows teachers to monitor students' interaction with learning resources and game elements and adapt tailored missions for students in gamified educational systems. The results indicate that the teachers have significantly good behavioral intention to use our tool and good perception of its usefulness and ease of use. The teachers also indicated enjoyment, relevance, and self-efficacy.*

Resumo. *Para melhorar os resultados de aprendizagem dos alunos, pesquisadores e profissionais têm aplicado cada vez mais a gamificação em ambientes de aprendizagem aprimorados por tecnologia. No entanto, alguns estudos na literatura relataram inesperados resultados negativos. Portanto, para evitar esses resultados inesperados em sistemas de aprendizagem gamificado, propusemos o "modelo de análise de gamificação para professores" em um estudo anterior. Esse modelo permite que os professores monitorem e adaptem o design da gamificação durante o processo de aprendizagem. Neste artigo, apresentamos os resultados obtidos em um estudo empírico para avaliar a percepção e aceitação dos professores em relação à ferramenta GamAnalytics, uma ferramenta desenvolvida com base no nosso modelo proposto que permite aos professores monitorar a interação dos alunos com recursos de aprendizagem e elementos de jogo e adaptar missões para estudantes em sistemas educacionais gamificados. Os resultados indicam que os professores têm uma intenção comportamental significativamente boa de usar nossa ferramenta e uma boa percepção de sua utilidade e facilidade de uso. Os professores também indicaram prazer, relevância e autoeficácia.*

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1. Introduction

Researchers have been pointing out the effectiveness of several educational technologies on students' learning outcomes [Yuwono and Sujono 2018]. Nevertheless, there are still major challenges related to the motivation, user activity, and retention of students when using educational technologies. Previous studies have indicated that the boredom state might be very persistent across these systems [Baker et al. 2010, D'Mello and Graesser 2012], and this state can be associated with students' poorer learning [Baker et al. 2004].

Technology-enhanced learning environments may benefit from design features to prevent students from boredom state [Jackson and McNamara 2013]. Therefore, there is a growing interest in applying gamification – the use of game elements in non-game contexts [Deterding et al. 2011, Werbach and Hunter 2015] – in these environments to boost students' engagement, learning and motivation [Andrade et al. 2016, Dermeval et al. 2017]. Results from existing studies are increasingly showing some of the gamification benefits on users' psychological and behavioral outcomes, including in the educational context [Hamari et al. 2014, Subhash and Cudney 2018]. Conversely, results from other existing studies have reported unexpected outcomes concerning students' motivation, engagement, and learning after applying gamification in some educational learning environments [Snow et al. 2015, Orhan Göksün and Gürsoy 2019]. As argued by researchers, the applied gamification design could be one of the possible causes of these negative results [Kapp 2012, Domínguez et al. 2013].

To avoid unexpected negative outcomes on the use of gamification, previous researches are investigating the use of a "gamification analytics" approach, which is defined as "the data-driven processes of monitoring and adapting gamification designs" [Heilbrunn et al. 2017]. This approach can give valuable insights to take corresponding actions towards gamification goal achievement [Heilbrunn et al. 2017]. Therefore, considering that teacher's participation is of utmost importance to the success of educational technologies [Macleod and Sinclair 2017], we proposed the "gamification analytics model for teachers" in a previous study [Tenório et al. 2020b]. According to this model, teachers can monitor and adapt gamification design during the learning process in gamified learning systems. As such, teachers can define interaction goals, monitor students' interaction with learning resources and game elements, and adapt gamification design through the use of missions, an effective element to motivate students during the learning process [Paiva et al. 2016].

In this paper, we evaluate teachers' perception and acceptance regarding a tool, named GamAnalytics, that takes advantage of the "gamification analytics model for teachers" to allow teachers to monitor and adapt gamification design in educational systems. We evaluate this tool by surveying with 57 teachers regarding several metrics – inspired on the Technology Acceptance Model (TAM) [Venkatesh and Bala 2008] – perceived usefulness, perceived ease of use, behavioral intention, relevance, perceived enjoyment, self-efficacy, computer anxiety.

2. Gamification Analytics Model for Teachers and GamAnalytics Tool

As previously mentioned, according to the "Gamification Analytics Model for Teachers" [Tenório et al. 2020b], teachers can define interaction goals, monitor students' interaction

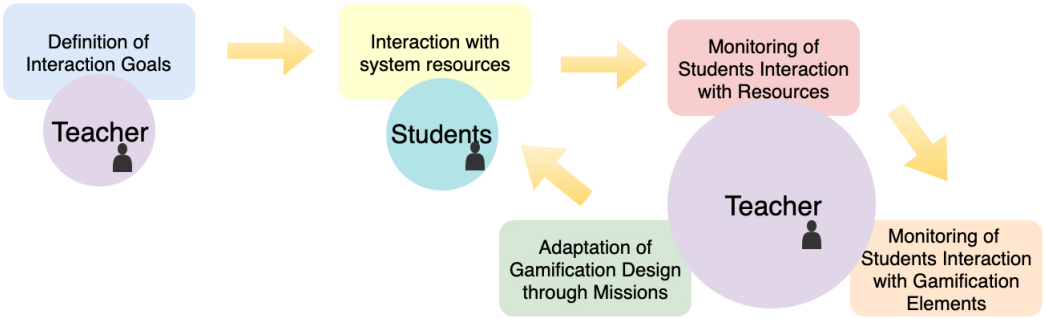

Figure 1. Gamification Analytics Model for Teachers. Source: [Tenório et al. 2020b]

with the learning resources and the gamification elements, and adapt the gamification design through missions for students that are not achieving the goals in gamified learning systems (Figure 1). Based on this model, we developed the GamAnalytics tool. The design concepts implemented in the GamAnalytics tool were validated with teachers through the "speed dating" method to respect their needs [Tenório et al. 2020b] . This method is designed to help researchers/designers reveal unmet needs not easily discovered through field observations [Holstein et al. 2017]. The tool provide teachers a way to intuitively monitor students' interaction with learning resources and game elements through dashboards and raise their awareness concerning class' status concerning the interaction goals. Moreover, teachers can adapt the gamification design creating missions for students that are not achieving the interaction goals defined. GamAnalytics tool was integrated to a gamified adaptive educational environment, named Avance (`https://avance.eyeduc.com`), and includes two types of dashboards (class' dashboard and individual student's dashboard), and a mission creation's page [Tenório et al. 2020a], as shown in Figure 2.

Class' dashboard: In the class' dashboard, several visualizations are shown through descriptive data and graphs for each topic of each course taught by the linked teacher: (1) quantity of students registered in the course; (2) the period expected for students to achieve the interaction goals; (3) the class' progress over time about interaction with learning resources; (4) the quantity and names of the students that achieved and did not achieved the interaction goals; (5) the quantity and names of the students that interacted (with success or not) or not interacted with each learning resource; (6) the quantity and names of the students that are in each level of gamification; and (7) the quantity and names of the students that achieved, not achieved or not attempted each mission created by the teacher during the learning process.

Individual student's dashboard: In the student's dashboard, some visualizations are presented to teachers by showing descriptive data and graphs: (1) student' basic info (e.g. name, and email); (2) student' gamification info such as points, current level, and position in the ranking; (3) student' progress over time about interaction with learning resources; and (4) student' interaction with each system's learning resource.

Missions creation's page: In the mission creation's page, teachers can define the

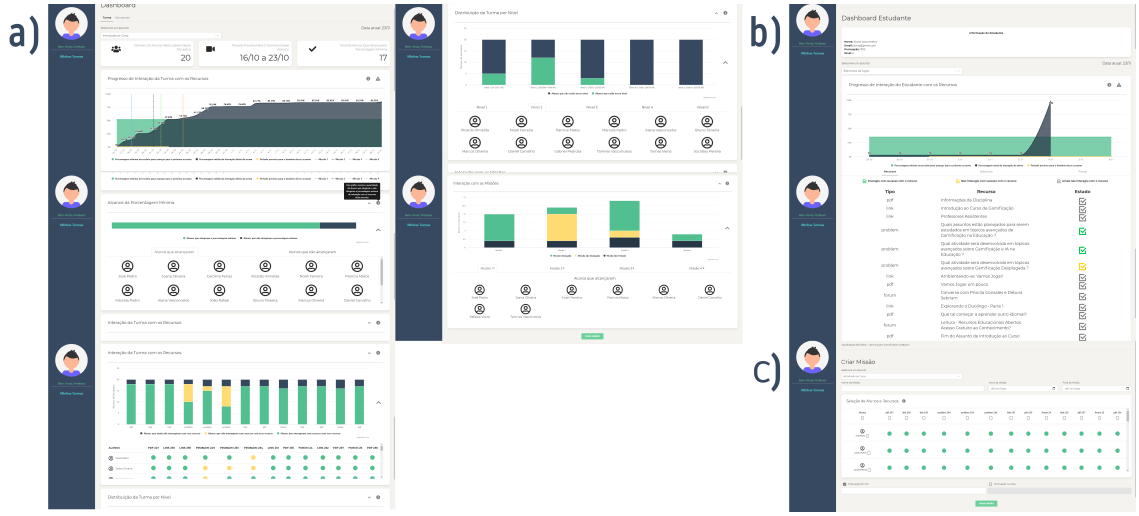

Figure 2. GamAnalytics Tool: Class (a) and individual (b) students' dashboards showing the topic's interaction goals, students' interaction with resources, and game elements, (c) missions creation's page.

mission's name, the period in which the mission will be available in the gamified learning system. Also, teachers can select which resources will comprise the mission, as well as the students who will be targeted by the mission. Finally, teachers can choose the mission reward for successful students, and these rewards can be given through XP points or an increase in the students' grades.

3. Validation of the GamAnalytics Tool

3.1. Materials and Methods

We conducted an empirical study to evaluate teachers' perceptions and acceptance concerning the GamAnalytics tool. Therefore, the GamAnalytics tool was analyzed by 57 teachers, invited through email, regarding the perceived usefulness (PU), perceived ease of use (PEOU), behavioral intention (BI), relevance (REL), perceived enjoyment (ENJ), self-efficacy (CSE), and computer anxiety (CANX). We evaluated these characteristics through the Technology Acceptance Model (TAM) – the most popular instrument to assess the Information Technology adoption and use [Venkatesh and Bala 2008]. We also evaluated the credibility (CR) of the tool [Dermeval and Bittencourt 2020], and its positive and negative aspects through a qualitative analysis of opinions reported.

The procedure for conducting this study was as follows. Through an online instrument, available during two months, teachers have read about the research objective and accepted the consent term to participate in the study. Afterward, teachers answered a questionnaire with their demographic information (age, gender, educational level[1], and the subjects that they teach). We also provided a brief explanation for the teachers about the Gamification Analytics model, and they watched a video tutorial that explains how to use the tool. Then, teachers interacted with the prototype of the GamAnalytics tool in which they monitored students' interaction with the learning resources and gamification elements, and created a mission. When the teachers finished their task, they answered

[1]We adopted the USA's educational level classification [Corsi-Bunker 2000]

a questionnaire that comprises twenty-six items: twenty-three of them corresponding to the TAM instrument, measured through 7-point Likert scale questions from 1 (strongly disagree) to 7 (strongly agree); one question to gather their opinion about the tool's credibility (measured through a scale from 1 to 10); and two optional open questions to gather the teachers' opinions about the positive and negative aspects of the tool.

3.2. Data Analysis

We adopted a mixed data analysis method for the questionnaire responses. In the quantitative analysis, besides the descriptive statistic, we performed a Pearson's chi-square goodness-of-fit test [Sharpe 2015] to determine whether there is a statistically significant difference between the expected frequencies and the observed frequencies in the questionnaire responses. For this analysis, we employed the average of items related to each latent factor measured by the TAM instrument to classify the observed responses into the following mutually exclusives classes: poor (for the average values of 1 to 3), fair (for the average values of 3 to 5), and good (for the average values of 5 to 7). The null hypothesis for the chi-square test stated that there was no significant difference in the frequencies responses in one of these classes. Before conducting the quantitative analysis, we assessed the reliability of our questionnaire using Cronbach's Alpha. The overall reliability for all the items indicates a good internal consistency ($\alpha = 0.841$), and the Cronbach's alpha for all the subscales of the TAM model was greater than 0.70s. Also, the majority of the Cronbach's alpha for these subscales indicate good internal consistency (0.80s). The qualitative data collected was examined using an open coding scheme [Corbin and Strauss 2008], which is the analytic process through which concepts are identified in data. Therefore, teachers' answers were grouped into categories to get a better understanding of their opinions.

3.3. Results

This section presents the findings of the data analysis performed on the responses gathered through the questionnaire answered by the teachers in the study. Most of them were teachers between 41 and 65 years (30 teachers - 52.63%) and between 26 and 40 years (24 teachers - 42.10%). The majority of participants were male teachers (32 teachers - 56,14%). The participant teachers teach in the post-secondary (43 teachers - 75,43%), post-baccalaureate (14 teachers - 24,56%), secondary school (5 teachers - 8,77%) and elementary school (3 teachers - 5,26%) educational level. Note that eight teachers (14,03%) pointed out that they teach at more than one educational level. Finally, the subjects that the participants teach were the science/biology (11 teachers - 19,29%), social studies (10 teachers - 17,54%), IT (6 teachers - 10,52%), languages and (4 teachers - 7,01%) and engineering (4 teachers - 7,01%).

3.3.1. Quantitative Analysis Results

Table 1 shows the statistic descriptive of all factors (7-point Likert scale) related to the TAM instrument, and the 10-point Likert scale question related to the teachers' credibility (CR) opinion. The results of chi-square tests performed on the frequencies of observed responses are presented in Table 2. According to these results, there are significant differences in all the latent factor measured by the TAM instrument.

Table 1. Summary of descriptive statistics for the questionnaire

Descriptive Statistics	PU	PEOU	BI	REL	ENJ	CSE	CANX	CR
Minimum	4.771	5.263	4.561	5.456	4.684	4.421	2.017	4.0
Maximum	5.368	5.701	5.491	5.561	5.526	5.210	2.192	10.0
Mean	5.192	5.482	5.093	5.502	5.187	4.842	2.128	8.105
Standard Deviation	0.894	0.663	0.479	0.054	0.443	0.397	0.094	1.410

The frequency distribution of teachers' responses is significantly different for the Perceived Usefulness ($\chi^2 = 6.333$ and $p = 0.011$). Most teachers (38 out of 57 teachers − 66,66%) indicated well-perceived usefulness for the GamAnalytics tool (see Table 2). The mean overall of this latent factor for all respondents was 5.192, indicating that teachers' evaluation concerning the usefulness of the tool was positive (see Table 1).

Concerning the Perceived Ease of Use, the mean overall of this factor was 5.482, a high rating value (see Table 1). Furthermore, the frequency distribution of observed responses was significantly different ($\chi^2 = 58.210$ and $p < 0.001$). The majority of teachers (46 out of 57 teachers − 80.70%) agree that GamAnalytics is an easy-to-use tool (see Table 2). Only three (03) teachers gave low ratings regarding the ease of use of the tool. A possible reason that might explain what has happened is that these teachers have low experience with the use of information technology in education. This result might suggest that, although the GamAnalytics tool is perceived as intuitive, some barriers must be overcome to improve its adoption, particularly, for teachers who are not familiar with information technology.

Table 2. Chi-square test concerning the acceptance of the GamAnalytics Tool

Factor	Poor	Fair	Good	χ^2	p-value
Perceived Usefulness (PU)	0	19	38	6.333	0.011
Perceived Ease of Use (PEOU)	3	8	46	58.210	<.001
Behavioral Intention (BI)	4	17	36	27.263	<.001
Relevance (REL)	2	7	48	67.052	<.001
Perceived Enjoyment (ENJ)	1	20	36	32.316	<.001
Self-efficacy (CSE)	5	24	28	15.895	<.001
Computer Anxiety (CANX)	1	11	45	56.000	<.001

The mean overall of the behavioral intention factor was 5.093 (see Table 1), which indicates a satisfactory outcome. Moreover, as shown in Table 2, the frequency distribution of teachers' responses is significantly different (χ^2 = 27.263 and p <.001), most of the teachers (36 out of 57 teachers − 63,15%) answered that they are willing to use the GamAnalytics tool. Regarding the relevance, it is important to note that this factor was the best-evaluated factor by the teachers, the mean overall was 5.502, as shown in Table 1. Moreover, the frequency distribution of observed responses was significantly different (χ^2 = 67.052 and p <.001), and the majority of teachers (48 out of 57 teachers − 84.21%) highly agreed that GamAnalytics tool is relevant for them (see Table 2). Therefore, it is an indication that teachers believe that the tool applies to his or her educational context and practice.

The perceived enjoyment in using the GamAnalytics tool by the teachers was

also well evaluated. The mean overall of this factor was 5.187, which means a highly satisfactory result, as seen in Table 1. Furthermore, the frequency distribution of teachers' responses is significantly different (χ^2 = 32.316 and p <.001), the majority of teachers (36 out of 57 teachers − 63.15%) highly agreed that GamAnalytics is an enjoyable tool to use (see Table 2). As also shown in Table 1, the mean overall of the self-efficacy factor was 4,842, indicating that the participants' assessment was positive. Besides, according to Table 2, teachers' responses are significantly different for the self-efficacy (χ^2 = 15.895 and p <.001), almost the majority of teachers' beliefs about their personal ability to use the GamAnalytics tool was high (28 out of 57 teachers − 49.12%).

Teachers‘ apprehension or even fear when they were interacting with the GamAnalytics tool was low. According to Table 1, the mean overall of the Computer Anxiety factor was 2.120. Furthermore, the frequency distribution of observed responses was significantly different (χ^2 = 56.000 and p <.001), the majority of teachers (45 out of 57 teachers − 78,94%) highly agreed that GamAnalytics does not cause anxiety, as seen in Table 2. Moreover, from a 1 and 10 score, the tool's average credibility was 8.105, which may suggest that teachers' perception of the credibility of the GamAnalytics tool is highly satisfactory, as seen in Table 1.

3.3.2. Qualitative Analysis Results

Of the 57 survey participants, 17 teachers pointed out the tool's positive points and 4 teachers pointed out negative points. Teachers' positive opinions were classified into three categories: usefulness, ease of use, relevance. In the following, we present some of those answers.

Usefulness: 1. "Through the use of the tool, the teacher can monitor the student's performance daily, using it as an evaluation criterion and creating strategies to improve the results". **2.** "When you become familiar with the tool, the method is certainly very useful". **3.** "When there are full conditions of use (structural and technical), it can be very useful and effective in achieving its purpose".

Ease of Use: 1. "Easy handling; Pleasant environment; Clarity in the information presented." **2.** "The interface is easy to use, even without a tutorial or video, it is easy to navigate." **3.** "I liked the fluidity of the navigation in the system; The system is very straightforward, with no factors to confuse." **4.** "The tool expresses a plausible teaching dynamic. I liked the way the mission ideas were conceived." **5.** "The tool is easy to use and allows you to easily and directly follow the evolution of each student in the discipline." **6.** "The charts and the "friendly" way in which the tool was presented make it easy to use and self-instructive."

Relevance: 1."Very current theme and product with a very valid proposal, the market demand for a solution like this is very high." **2.** "The effort of research to develop something for the optimization of gamification is something positive."

The teachers' negative answers were classified into two major categories: usefulness, ease of use. The following are some of the teachers' responses.

Usefulness: 1. "As the classes are eclectic, the tool does not anticipate the daily problems that students may face, causing them to have low learning performance." **2.**

"Some complementary functions can be added to improve the environment, for example, automating through AI the inclusion of new missions."

Ease of use: 1. "Confusing interface." **2.** "For those who do not master computational environments, game logic, etc., I find its use very difficult. The tool could be more self-explanatory. Before using it, an explanation about its use is needed in a more interactively, easy for those users who do not have affinities with the computational environment. Not all teachers have mastered or can master/understand the computational resources for the adequate/effective use of this tool. "

4. Discussion, Conclusion, and Limitations

In this work, teachers' perceptions concerning the GamAnalytics tool were evaluated regarding the perceived usefulness, perceived ease of use, behavioral intention, job relevance, perceived enjoyment, self-efficacy, and computer anxiety factors. According to the quantitative results, most teachers participants' perceptions concerning the GamAnalytics tool are positive, mainly related to the perceived ease of use and relevance.

Regarding the qualitative results, most results were positive. Teachers mainly pointed out that the tool is useful, easy of use, and relevant for their jobs. They also indicated that the tool is easy to use, since, 10 from 17 responses mentioned the positive aspects of the ease of use of the tool. This result may suggest that the tool has achieved the goal of being intuitive and does not require high effort from teachers to use it. Four teachers also talked about the usefulness of the tool, pointing out that the tool can effectively assist them in monitoring and adapting the gamification design and, thus, improving the students' learning, engagement, and motivation results. Finally, three teachers pointed out that the purpose of the tool is relevant to them.

The number of responses from teachers indicating negative points was quite low (4 answers) compared to the number of answers indicating positive points (17 answers). This is evidence that the teachers evaluated the tool more positively than negatively. Two teachers expressed their opinion concerning the usefulness of the tool. The first one pointed out that the tool cannot detect daily problems that students may face and this could harm students' learning performance. The second teacher pointed out that the tool could obtain better results including artificial intelligence for the creation of missions. Finally, two teachers criticized the ease of use of the tool, saying that the tool is confusing and that it needs to be better explained to teachers who are not familiar with computational environments and game logic.

This study presents some validity threats. There were many questions to evaluate different factors in the survey applied to the teachers. As such, the survey may have been tedious for respondents to complete, and the quality of the data may, consequently, have decreased. Furthermore, due to the number of survey participants, there is a risk that the participants do not significantly represent the population of interest, making it difficult to generalize the reported results. However, to minimize this threat, we considered teachers of different educational levels, domains, locals in our study.

Therefore, the negative opinions we received from teachers will be useful to improve future versions of the GamAnalytics tool. The tool could be complemented by applying artificial intelligence techniques to generate automated missions to students.

Artificial intelligence can be used to help teachers identify appropriate situations to assign missions as well as to identify students at risk of not achieving learning goals, helping teachers in pedagogical decision-making. Furthermore, nine teachers indicated that they could not point out the negative points of the tool before using it effectively in a real class. These opinions highlight the need to evaluate the tool in real-life scenarios with teachers using the tool proposed daily in their educational contexts. We intend to investigate these issues in further research.

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