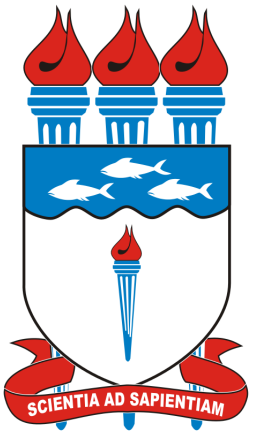

Federal University of Alagoas
Computing Institute
Graduate Program in Computational Knowledge Modeling

Gamification Analytics Model for Teachers

Kamilla Kemilly Tenório Alves dos Santos

Maceió-AL

April, 2020

Kamilla Kemilly Tenório Alves dos Santos

Gamification Analytics Model for Teachers

Master thesis presented as partial requirement to obtain the master's degree by the Graduate Program in Computational Knowledge Modeling of the Federal University of Alagoas.

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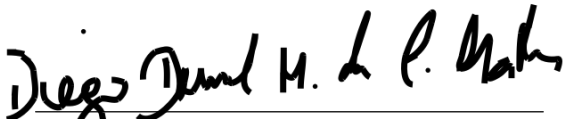

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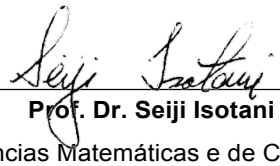

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To my family...

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"Now I remembered that the real world was wide, and that a varied field of hopes and fears, of sensations and excitements, awaited those who had courage to go forth into its expanse, to seek real knowledge of life amidst its perils."

(BRONTË, 1847)

RESUMO

Apesar dos resultados positivos obtidos através da aplicação da gamificação no contexto de aprendizagem aprimorada por tecnologia, alguns estudos encontrados na literatura relataram resultados não esperados em relação ao engajamento, a aprendizagem e a motivação dos alunos em sistemas de aprendizagem gamificados. Portanto, com o intuito de evitar possíveis resultados negativos, esta dissertação propõe o "modelo de monitoramento e adaptação do design da gamificação para professores". Nesse modelo, o professor pode definir metas de interação, monitorar a interação dos alunos com os recursos de aprendizagem do sistema e com os elementos de gamificação e adaptar o design da gamificação por meio do uso de missões para engajar e motivar os alunos que não estão atingindo as metas de interação definidas/esperadas. No entanto, os conceitos de design baseados no refido modelo que serão implementados em futuros sistemas de aprendizagem gamificados devem ser bem planejados para respeitar as necessidades dos professores. Consequentemente, uma das contribuições desta dissertação é a validação de 20 conceitos de design baseados no modelo feita com professores por meio do método "speed dating". Após esta fase, os conceitos de design mais bem avaliados forneceram informações relevantes para orientar o design e o desenvolvimento de uma ferramenta, chamada GamAnalytics, que visa permitir que os professores adaptem o design gamificado de sistemas de aprendizagem durante o processo de aprendizado, com base no monitoramento de painéis que expõem informações relevantes dos alunos sobre sua interação com os recursos de aprendizagem e com os elementos de gamificação de maneira intuitiva e significativa. Além disso, os professores avaliaram on-line a ferramenta desenvolvida, onde foram medidas as seguintes métricas: utilidade percebida, facilidade de uso percebida, intenção comportamental, relevância, prazer percebido e autoeficácia. Os resultados mostraram uma alta aceitação e aprovação pelos professores da ferramenta proposta em relação às métricas medidas. Além do mais, para investigar o impacto do uso do modelo por professores através da ferramenta GamAnalytics no engajamento, aprendizagem e motivação dos alunos, foi conduzido um estudo de caso. O estudo de caso foi conduzido durante quatro semanas e foi realizado com estudantes de graduação e pós-graduação da Universidade Federal de Alagoas, matriculados no curso "Gamificação na Educação". Os resultados sugerem uma melhoria no engajamento dos alunos, nos resultados de aprendizagem e um efeito positivo na motivação dos alunos.

Palavras-chaves: Gamificação. Ambientes educacionais gamificados. Tomada de decisão informada por dados.

ABSTRACT

There is a growing interest in applying gamification in technology-enhanced learning environments in order to keep students engaged and motivated during the learning process. Although the positive outcomes obtained through the application of gamification in the technology-enhanced learning context, some studies found in the literature reported unexpected results concerning students' engagement, learning, and motivation in gamified learning systems. A possible solution to avoid these unexpected outcomes is to monitor and adapt the gamification design of gamified learning environments during the learning process when the targeted objectives are not being achieved. Moreover, considering that the existence of teachers is essential to the success of education, teachers could be responsible to monitor and adapt gamification design in these environments. However, there is a lack of contributions in the literature that allows teachers to monitor and adapt gamification design of gamified e-learning environments in an intuitive, meaningful, enjoyable way and with no advanced technical skills required. Therefore, this dissertation proposes the "gamification analytics model for teachers". In this model, the teacher is allowed to define interaction goals, monitor students' interaction with the system' learning resources and the gamification elements and adapt the gamification design through missions to engage and motivate students that are not achieving the interaction goals defined. However, the gamification analytics model-based design concepts that will be implemented in the future in gamified learning systems should be well planned to respect the teachers' needs. Consequently, one of the contributions of this dissertation is the validation made by teachers of 20 gamification analytics model-based design concepts through the speed dating method. Therefore, the most well-rated design concepts provided relevant insights to guide the design and the development of a tool, called GamAnalytics, that aims to allow teachers to adapt the gamified design of gamified learning systems during learning process based on monitoring of dashboards that expose students' relevant information about their interaction with learning resources and gamification elements in an intuitive and meaningful way. Moreover, teachers evaluated the developed tool online where perceived usefulness, perceived ease of use, behavioral intention, relevance, perceived enjoyment, and self-efficacy metrics were measured. Results showed a high acceptance and approval of the proposed tool by teachers concerning the measured metrics. Furthermore, in order to investigate the impact of the use of gamification analytics models by teachers through the GamAnalytics tool on students' engagement, learning, and motivation, a case study was conducted. The case study took place for four weeks, and it was conducted with undergraduate and graduate students of the Federal University of Alagoas who were enrolled in the "Gamification in Education" course. Finally, the results suggest an improvement in students' engagement, learning outcomes and a positive effect on students' motivation.

Keywords: Gamification. Gamified Learning Environments. Data-informed decision-making. Gamification analytics.

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LIST OF ABBREVIATIONS AND ACRONYMS

ICT	Information and Communication Technologies
GLE	Gamified Learning Environment
HCI	Human-Computer Interaction
KPI	Key Performance Indicator
IMI	Intrinsic Motivation Inventory
IMMS	Instructional Materials Motivation Survey

CONTENTS

1 INTRODUCTION

The objective of this chapter is to present the context, motivation (Section 1.1) and the problem (Section 1.2) of this work. Moreover, the objective (Section 1.3), the method (Section 1.4), and the document organization (Section 1.5) are also specified.

1.1 Context and Motivation

The rise and institutionalization of Information and Communication Technologies (ICT) allowed the transformation of many human activities, including education (MUÑOZ et al., 2016). Due to this change, traditional educational approaches have been adapted in order to promote and support the use of technologies on both on-line learning courses and classroom courses (TENORIO et al., 2016). A popular effective learning approach is e-learning (MOTHIBI, 2015). E-learning involves utilization of information and communication technology (ICT) to improve and help teaching and learning (MOTHIBI, 2015) through educational activities that are carried out by individuals or groups working online or offline, and synchronously or asynchronously via networked or standalone computers and other electronic devices (NAIDU, 2006).

Although recent meta-analysis and meta-reviews support the effectiveness of e-learning environments (YUWONO; SUJONO, 2018), (CABERO-ALMENARA; MARÍN-DÍAZ; SAMPEDRO-REQUENA, 2016), (MOTHIBI, 2015), (MA et al., 2014), (KULIK; FLETCHER, 2016), (STEENBERGEN-HU; COOPER, 2013), (STEENBERGEN-HU; COOPER, 2014) (VANLEHN, 2011), some studies pointed out that boredom state is very persistent across these systems (BAKER et al., 2010) (BELL; MCNAMARA, 2007). Research show that within computer-based learning environments, boredom leads to gaming the system, which consists of attempting to succeed in an interactive learning environment by exploiting properties of the system rather than by learning the material (BAKER et al., 2010), and also leads to off-task behavior, which consists of behaviors that do not involve the learning software or its domain in any way (BAKER et al., 2011). Moreover, both gaming the system and off-task behavior are associated with poorer learning (BAKER et al., 2004) (KARWEIT; SLAVIN, 1982).

Nonetheless, e-learning environments may benefit from design features that enhance students‘ engagement in order to prevent students from boredom state (JACKSON; MCNAMARA, 2013). Therefore, there is a growing interest in applying gamification in e-learning (TENORIO et al., 2016), (ANDRADE; MIZOGUCHI; ISOTANI, 2016), (GONZÁLEZ; TOLEDO; MUÑOZ, 2016) (SHI; CRISTEA, 2016), (DERMEVAL et al., 2017), which is the use of game-based elements in non-game contexts to motivate and increase user activity and retention (DETERDING et al., 2011). Research (HAMARI; KOIVISTO; SARSA, 2014) point out the benefits

of gamification in users' psychological and behavioral outcomes, including in the educational context (SUBHASH; CUDNEY, 2018) (ORTIZ; CHILUIZA; VALCKE, 2016).

However, despite the positive impact on students' motivation and learning through the use of gamification (LATULIPE; LONG; SEMINARIO, 2015) (BORRAS-GENE; MARTINEZ-NUNEZ; BLANCO, 2016), studies found in the literature have reported not expected outcomes applying this approach (SNOW et al., 2015) (DOMÍNGUEZ et al., 2013) (HANUS; FOX, 2015) (GÖKSÜN; GÜRSOY, 2019). Experts point out that the applied gamification design is one of the possible causes of negative results (KAPP, 2012) (DOMÍNGUEZ et al., 2013). The process to design gamification should incorporate different aspects such as the personas of involved users, the application's domain, properties of the gamified application itself, or legal constraints (HEILBRUNN; HERZIG; SCHILL, 2017). These diverse aspects are subject to change over time, so gamification design must not be rigid (HEILBRUNN; HERZIG; SCHILL, 2017), so they should be monitored and adapted when goal achievement is not being reached. Based on this argument, monitor and analyze data related to gamification can give valuable insights to take corresponding actions towards goal achievement (HEILBRUNN; HERZIG; SCHILL, 2017). Heilbrunn, Herzig and Schill (HEILBRUNN; HERZIG; SCHILL, 2017) named this process as gamification analytics, and defined as "the data-driven processes of monitoring and adapting gamification designs". Nonetheless, the studies that address gamification in e-learning environments are not concerned in monitoring and adapting gamification design during learning process, neither through automated adaptation nor through human decision-making, meaning a greater risk in obtaining not expected results (TRINIDAD; CALDERÓN; RUIZ, 2018).

Considering that we are entering in an era where data is being more used in the service of human decision-making and design than automated adjustment (BAKER, 2016) (CUKUROVA; KENT; LUCKIN, 2019), and that teachers should be at the heart of most ICT for education programmes (UNICEF, 2018) (MACLEOD; SINCLAIR, 2017), teachers could be the responsible to monitor and adapt gamification design in e-learning systems. Teachers believe that gamification has the capacity to draw students' attention, motivate students to engage, facilitate students' learning (SANCHEZ-MENA; MARTI-PARREÑO, 2017) and the teachers' attitude towards gamification are positive and high (MARTÍ-PARREÑO; SEGUÍ-MAS; SEGUÍ-MAS, 2016). However, there are barriers that prevent teachers from using gamification (SANCHEZ-MENA; MARTI-PARREÑO, 2017). A study with student teachers presented a high and positive correlation between their satisfaction with the use of gamification and the perceived ease of use, meaning that gamification use should be easy enough to enable student teachers handle this innovative educational technology (GALBIS-CORDOVA et al., 2016). Therefore, it is necessary to investigate potential solutions to allow teachers to monitor and adapt gamification design in the e-learning environments in a simple, usable way and with no advanced technical skills required.

1.2 Problem

Innovations in technologies-enhanced learning context are providing a revolution in education, and consequently transforming the role of teachers (JETHRO; GRACE; THOMAS, 2012), expecting them to become technologically oriented (AMIN, 2016). Despite the rapid technological advance of these environments, the existence of teachers is essential to the success of education (UNICEF, 2018) (MACLEOD; SINCLAIR, 2017). A demonstration of the importance of teachers, it is that the lack of their presence is likely one of the biggest barriers to the accessibility of digital learning in education (MACLEOD; SINCLAIR, 2017). Even AI-enhanced educational systems that learn through the students' inputs and offer content in a personalized way (IZUMI; FATHERS; CLEMENS, 2013), thus potentially substituting teachers' basic role of instruction, face barriers as low rate of adoption and use due to the lack of support for teachers (NYE, 2014) (UNESCO, 2019)(PINKWART, 2016).

Based on this, e-learning systems are more concerned in applying techniques that support teachers integrate educational technologies into their pedagogy in order to obtain educational success, rather than replacing them, putting teachers at the frontline of education. One example is the use of students‘ interaction data that is routinely collected by educational technologies to help teachers decision-making process (PAIVA et al., 2016) (PAIVA et al., 2015) (PRENGER; SCHILDKAMP, 2018), offering the possibility of teachers visualizing data related to students' performance and their progress over time (MOLENAAR; CAMPEN, 2018). Therefore, when students performance is not progressing as expected, teachers intervene through pedagogical actions (MOLENAAR; CAMPEN, 2018).

In gamified e-learning systems, educational systems that apply game elements in order to motivate and increase user activity and retention, (DETERDING et al., 2011) (ZICHERMANN; CUNNINGHAM, 2011)(KAPP, 2012), are not achieving the expected results. One of the possible reasons for this is the lack of monitoring and adaption of gamification design during the learning process, considering this approach could decrease the chances of obtaining unexpected negative results. Therefore, considering the important role of teachers in educational systems, discussed above, they could be responsible to monitor students‘ interactions with learning resources and gamification elements and intervene through adaptation of gamification design when detecting a decrease of students‘ interaction. Moreover, this approach also can increase teachers' positive perception of the application of gamification in education.

However, studies found in the state of art in the field of gamification analytics (i.e data-driven processes of monitoring and adapting gamification designs) are targeted to gamification experts (HEILBRUNN; HERZIG; SCHILL, 2017; HERZIG; AMELING; SCHILL, 2012) (CALDERÓN; BOUBETA-PUIG; RUIZ, 2018). Therefore, the solutions provided in the literature to monitor and adapt gamification design are complex to be used by teachers. In view that the target audience of this dissertation proposal are teachers and they do not have the skill, nor the time to use or learn how to use complex tools (MURRAY, 2016), it is need to

design a solution where the complexity capacity for monitoring, and adapting the gamification design be low.

Considering the aforementioned discussion, the problem of this dissertation is:

RQ: "How to develop a solution that allows teachers to monitor and adapt gamification design of gamified e-learning environments in an intuitive, meaningful, enjoyable way and with no advanced technical skills required?".

1.3 Objective

Based on the aforementioned problem, the main objective of this work is to enable teachers to monitor and adapt the gamification design of gamified e-learning environments in a simple, intuitive, usable way and with no advanced technical skills required. Therefore, the proposed solution will rely on the gamification analytics and human-computer interaction research field to create an easy, meaningful and intuitive solution for teachers.

The specific objectives of this dissertation are:

O1: Based on the results of literature reviews concerning the research fields of gamification analytics and gamification in the technology-enhanced learning context, propose a model (*Gamification Analytics Model for Teachers*) that can be used by teachers that adopt gamified learning environments in order to allow them to adapt the gamification design during the learning process based on the monitoring of students' interaction with learning resources and gamification elements.

O2: Use methods of the human-computer interaction research field to validate the Gamification Analytics model-based design concepts, aligning with teachers‘ needs, in order to develop a computational environment where teachers can use it in an intuitive, meaningful, enjoyable, and effortless way.

O3: Implement a tool based on the Gamification Analytics Model for Teachers using the validated design concepts and integrate into a gamified learning environment.

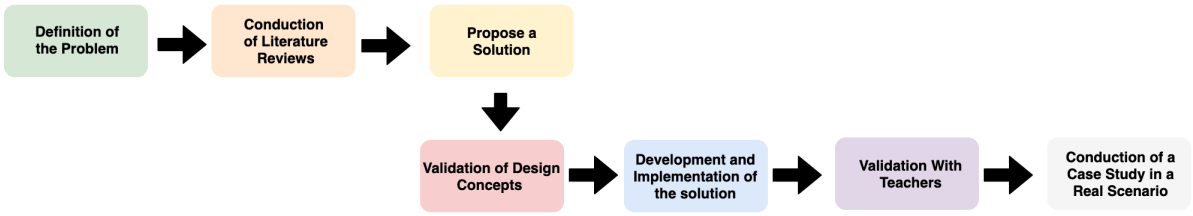
O4: Evaluate teachers‘ perceived usefulness, perceived ease of use, behavioral intention, relevance, perceived enjoyment, and self-efficacy of the implemented tool to verify whether it is intuitive, meaningful, enjoyable, and with no advanced technical skills required.

O5: Evaluate the impact of teachers' use of the gamification analytics model on students' learning, engagement, and motivation.

1.4 Method

The method followed to conduct this research can be seen in Figure 1.

Figure 1 – **Research Method**



Picture source: Author

Definition of the Problem: First, as depicted in previous sections of this chapter, the research problem of this dissertation was identified through a research review of recent challenges in the field study of gamification in the technology-enhanced learning context.

Conduction of Literature Reviews: After the definition of the research problem, literature reviews in the research field were conducted to propose the solution for the targeted problem, achieve the objectives of this work, and advance the state of the art based on the results reported in previous studies.

Propose a Solution: Based on the results obtained after the conduction of the literature reviews, a model (*Gamification Analytics Model for Teachers*) that can be used by teachers that adopt gamified learning systems was proposed to allow them to adapt the gamification design during the learning process based on the monitoring of students' interaction with learning resources and gamification elements.

Validation of Design Concepts: Before implementing the proposed model from a computational point of view, the design concepts that were included in the implemented technology based on the proposed model were validated to be aligned with the needs of the target audience of the contribution, the teachers. To accomplish it, the speed dating method, based on the HCI (Human-Computer Interaction) research, was adopted to discover unexpected design opportunities and unforeseen needs.

Development and Implementation of the Solution: After the validation of the gamification analytics model-based design concepts with teachers, a web-based tool was developed and the validated design concepts were implemented into it. Moreover, the tool was integrated with a gamified learning environment in order to conduct empirical validation.

Validation of the implemented solution with Teachers: To analyze whether the previously developed tool is intuitive, meaningful, enjoyable, and with no advanced technical skills required, a survey was conducted with teachers of different backgrounds and educational levels to validate the tool. Aiming to achieve this objective, teachers interacted with the tool and evaluated it regarding the perceived usefulness, perceived ease of use, behavioral intention, relevance, perceived enjoyment, and self-efficacy constructs.

Conduction of a Case Study in a Real Scenario: Finally, aiming to evaluate

the impact of teachers' use of the gamification analytics model through the GamAnalytics tool on students' learning, engagement and motivation, a case study was conducted in the "Gamification in Education" course.

1.5 Organization

The following sections of this work are organized into the following chapters:

Chapter 2: It is presented the main theoretical concepts and technologies that are used in order to develop this dissertation contribution, which include background about gamification, gamification analytics, and gamified learning environments.

Chapter 3: It is described how the literature was investigated and describe the main works that are related to this dissertation proposal.

Chapter 4: It is presented the Gamification Analytics Model for Teachers, the proposal presented to solve the targeted problem of this dissertation.

Chapter 5: It is explained about the speed dating method and how it was conducted with teachers to validate design concepts that can be implemented in systems that adopt the proposed gamification analytics model.

Chapter 6: It is presented the gamification analytics model-based tool (GamAnalytics tool) that was developed to enable teachers to monitor and adapt gamification design of gamified e-learning environments. Moreover, in this chapter is presented the gamified learning system Avance, which was integrated into the developed GamAnalytics tool.

Chapter 7: It is presented the research that was conducted with teachers to validate the GamAnalytics tool. The research intended to evaluate the GamAnalytics tool regarding perceived usefulness, perceived ease of use, behavioral intention, relevance, perceived enjoyment, and self-efficacy constructs, as well as verify the credibility of the tool and its positive and negative points according to teachers in order to improve future versions.

Chapter 8: It is presented the case study that was conducted to explore the impact of teachers' use of the gamification analytics model through the GamAnalytics tool on students' learning, engagement and motivation.

Chapter 9: Finally, it is presented the final considerations, pointing out the contributions and limitations of this dissertation, besides describing the future works.

2 THEORETICAL BACKGROUND

In this chapter, it will be presented the main theoretical concepts used in this dissertation. In the following, it will be described sections concepts regarding Gamification (Section 2.1), Gamification Analytics (Section 2.2), Gamified Learning Environments (Section 2.3).

2.1 Gamification

Gamification is a relatively new term, first used in 2008 in the digital media industry and widely adopted in 2011 (DETERDING et al., 2011), and there is a growing interest in this subject. Gamification was defined by diverse authors, and two of the most known definitions are:

"Gamification is using game-based mechanics, aesthetics, and game-thinking to engage people, motivate action, promote learning, and solve problems" (KAPP, 2012).

"Gamification is the use of game design elements in non-game contexts" (DETERDING et al., 2011).

According to Kapp (KAPP, 2012), gamification can be used to conquer a number of objectives related to learning, and it is especially effective when it is used to encourage learners to progress through content, motivate action, influence behavior, and drive innovation. However, in order to increase the chance to conquer these objectives, it is necessary to worry about the gamification design. In the process of designing gamification, it is essential to separate the high-level principles from the mid-level action structures and the surface-level manifestations (WERBACH; HUNTER, 2015). Therefore, Werbach, Hunter divided gamification elements according to their levels (dynamics, mechanics, components), as can be seen in the Figure 2.

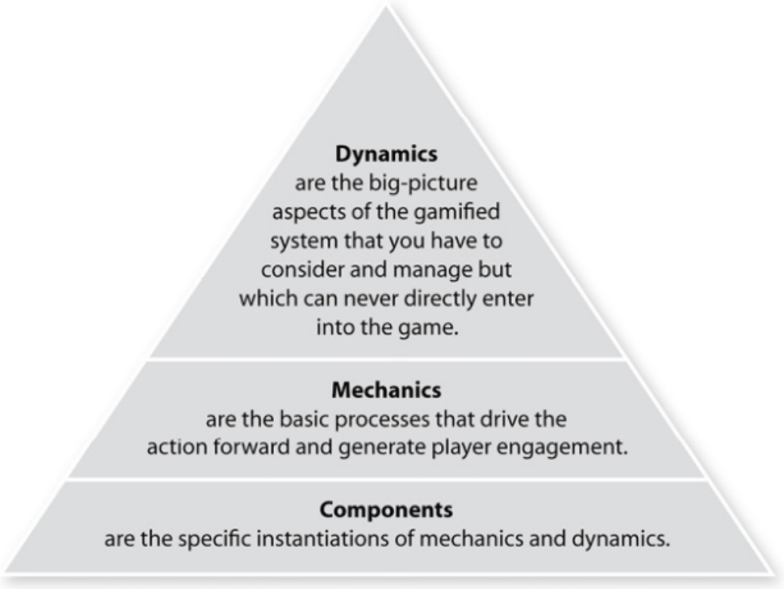
Dynamics: are the "big picture" aspects of the gamified system that should be considered and managed, but which can never directly enter into the game. The example of dynamics given by Werbach (WERBACH; HUNTER, 2015) are: constraints, emotions, narrative, progression and relationships.

Mechanics: are the basic processes that drive the action forward and generate player engagement. The example of mechanics given by Werbach (WERBACH; HUNTER, 2015) are: challenges, chance, competition, cooperation, feedback, resource acquisition, rewards, transactions, turns and win states.

Components: are the specific instantiations of mechanics and dynamics, the elements that players interact directly. The example of components given by Werbach (WERBACH; HUNTER, 2015) are: achievements, avatars, badges, boss fights, collections, combat, content

unlocking, gifting, leaderboards, levels,points, quests, social graphs, teams and virtual goods.

Figure 2 – **The Game Element Hierarchy**



Picture source: Werbach and Hunter (WERBACH; HUNTER, 2015)

2.1.1 6D Framework

The design phase in the gamification process can be crucial to the gamification success, so details should be well planned and well grounded. Some gamification models and frameworks can assist in this process, such as 6D framework (WERBACH; HUNTER, 2012), Octalysis framework (CHOU, 2015), GAFCC model (HUANG; HEW, 2018). According to Mora et al. (MORA et al., 2015), among the gamification design frameworks, the best-known one is the 6D framework (WERBACH; HUNTER, 2012). This framework is based on the Self-Determination Theory and is presented in six steps. The following steps will be described below:

1. Define Business Objectives: The first step on the gamification design includes defining the objective in using gamification in the working project. In Werbach and Hunter (WERBACH; HUNTER, 2012), it was established a process with three sub-steps in this activity: (i) make a list as concrete as possible and rank them; (ii) eliminate the things that are not a final business objective; and (iii) justify objectives;

2. Delineate target behavior: The second step on the gamification design includes the behaviors that are intended for the users to reach. In Werbach and Hunter (WERBACH; HUNTER, 2012), it was defined some steps that could be followed: (i) specify the tasks; (ii) define the success metrics, the win states for every tasks; and (iii) define the ways to measuring the win states.

3. Describe your players: The third step on the gamification design includes the

description of the users of a gamified system. It can consider demographics, age groups, kind of behavior, and so on (WERBACH; HUNTER, 2012).

4. Devise activity loops: The fourth step on the gamification design includes identifying and evaluating the repetitives and recoursives structures, which focuses on two kinds of tasks: engagement loops and progressive loops (WERBACH; HUNTER, 2012). In the engagement loops, tasks that wanted to be repeated by users should be identified, motivated, and feedback should be given to them. In these loops, there are three elements: (i) motivation: motivate the users to do something expected by the designers; (ii) action: where the user indeed do the task; (iii) feedback: an immediate feedback given to the user to become them motivated and iterate the loop. Progressive loops are included on the design to drive users from a beginner to a master of a task. These loops consider activities from start to finish and a set of intermediate steps. They also provide small challenges to the user to arrive to a final goal.

5. Don't forget the fun: The fifth step on the gamification design is the most subjective of all. It is about the importance of considering fun in the design of gamified systems.

6. Deploy appropriate tools: The sixth step on the gamification design includes considering all the necessary tools to apply dynamic, mechanics, and components considering the particularities of players as well as the loops to drive users to achieve the business objects in a funny way.

2.2 Gamification Analytics

As explained before, gamification is the use of game-based elements in non-game contexts to motivate and increase user activity and retention (DETERDING et al., 2011) (ZICHERMANN; CUNNINGHAM, 2011) (KAPP, 2012). According to Herzig et al. (HERZIG et al., 2015), the gamification process could be summarized in these four high-level phases:

1. Business Modeling and Requirements: where the application context is analyzed and business goals are documented.

2. Design: where the gamification design is developed and play tested.

3. Implementation: where the design is implemented as software artifacts and functionally tested.

4. Monitoring and Adaptation: where business goal achievement is measured and subsequent design adaptations are conducted.

The importance of the gamification design phase has been highlighted in numerous occasions (CALDERÓN; BOUBETA-PUIG; RUIZ, 2018). Since studies found in the literature have reported negative outcomes after the application of gamification without planning concerns (DOMÍNGUEZ et al., 2013) (**??**), experts point out that a bad gamification design is one of the main causes of these negative effects (KAPP, 2012) (DOMÍNGUEZ et al., 2013). Consequently,

a soundness design is a key factor to success in gamification (MORA et al., 2015).

Nonetheless, the process to design gamification is a creative aspect and should incorporate different aspects such as the personas of involved users, the application's domain, properties of the gamified application itself, or legal constraints (HEILBRUNN; HERZIG; SCHILL, 2017). These diverse aspects are subject to change over time, so gamification designs are not rigid artifacts (HEILBRUNN; HERZIG; SCHILL, 2017).

These are particular reasons, according to Heilbrunn, Herzig and Schill (HEILBRUNN; HERZIG; SCHILL, 2017), that make the design subject to change:

- The gamification design might not help to achieve the defined goals as expected;
- Certain gamification elements might not influence the behaviour of all targeted users in the intended way;
- Changes to the goal setting (e.g., due to organizational changes) might make an adaptation of the gamification design necessary;
- User engagement might slowly decrease in relevant metrics and as a result, existing gamification elements might be adjusted.

Therefore, the fourth phase of the gamification process, monitor and analyze data related to gamification, can give valuable insights to gamification experts, helping them to take corresponding actions towards goal achievements (HEILBRUNN; HERZIG; SCHILL, 2017). Heilbrunn, Herzig and Schill (HEILBRUNN; HERZIG; SCHILL, 2017) named this process as gamification analytics, and defined as "the data-driven processes of monitoring and adapting gamification designs".

In the systematic review conducted by Trinidad, Calderon and Ruiz (TRINIDAD; CALDERÓN; RUIZ, 2018) was stated that the monitoring phase of the gamification process is a crucial step in the life cycle of a gamification experience that needs to be supported by appropriate tools that support gamification experts to evaluate, improve on/and adapt gamification experiences. However, gamification analytics have not yet received significant attention from academics nor from a practical perspective.

2.2.1 User requirements for gamification analytics

Heilbrunn, Herzig and Schill (HEILBRUNN; HERZIG; SCHILL, 2014b) presented a theoretical model of 22 user requirements for supporting the monitoring and adaptation of gamification designs. The model presented can be used to assess existing solutions or construct novel methods and tools for gamification analytics. The model was validated by gamification experts.

The model comprises five categories of requirements: *Application KPI Monitoring, Gamification Element Analytics, Gamification Design Adaptation, User Groups of Interest,*

Simulation.

- **Application KPI Monitoring**

This category contains six requirements that are related to two aspects: "Definition of Application KPIs" and "Presentation of Application KPIs".

Definition of Application KPIs: Gamification literature emphasizes the importance of defining clear business goals and measuring the success of gamification designs towards their achievement. Key Performance Indicators (KPIs) based on user behavior can be used to operationalize business goals. Therefore, the collection of relevant data is one of the essential prerequisites for realizing gamification analytics. These are the following requirements related to "Definition of Application KPIs":

(R1) Custom KPIs: Gamified applications typically have domain-specific KPIs, so gamification experts should be able to define these KPIs. The definition of KPIs should be possible at any point of time, allowing experts to adjust and refine KPIs according to their informational needs and available event data(HEILBRUNN; HERZIG; SCHILL, 2014b).

(R2) Pattern Based KPIs: Experts should be able to formulate KPIs that count the number of particular pattern occurrences in the behavior data of users. This supports experts in measuring the success of game elements which aim at influencing behavior patterns.

(R3) KPI Goal Values: The experts should be able to define and adjust KPI goal values whose fulfillment will be monitored automatically by the gamification analytics system.

Presentation of Application KPIs: The following requirements are related to the presentation of application KPIs:

(R4) Dashboard: Gamification experts should be able to get a comprehensible overview of the state and over time development of application KPIs. This can be achieved by a visual dashboard that combines charts with descriptive statistics.

(R5) Change Markers: Experts should be able to understand the impact of historical changes in the gamification design on the development of application KPIs. This can be achieved by annotating KPI curves with markers that indicate past design changes.

(R6) Goal Markers: Experts should be aware of how individual KPIs perform in relation to their goal value. The defined KPI goal value should be shown together with the actual KPI value and deviations should be indicated. This might help experts to immediately notice undesired changes and gives them the chance to take appropriate action such as exploring the data for better insights or adapting the gamification design to increase engagement.

- **Gamification Element Analytics**

This category contains six requirements that are related to two aspects: "Game StateOverview" and "Detailed Statistics of Game Elements".

Game State Overview: Gamification experts should have an overview of the game state and its development over time. Exploring the relation between game states and the corresponding users might help experts to detect design flaws or other needs for design adjustment. These are the following requirements related to "Game State Overview":

(R7) Gamification Feedback Rate: Gamification Feedback is any state change in the game that is perceived by the user as success, e.g., gaining points, or receiving a badge. Consequently, the Feedback Rate describes the amount of feedback per time. Experts should be able to inspect the feedback rate over time, corresponding descriptive statistics, and annotations representing past design changes. This insight might help them to qualify all other observations, and can be a starting point for investigating unexpected user behavior.

(R8) Point Distributions: Experts should have insight into the distribution of points over users. This might help them to detect flaws in the balance of point amounts for gamified actions.

(R9) Achievable Game Elements: Gamification experts should have insight into the overall statistics of badges, levels, missions, and other achievable game elements. Moreover, they should see the users' progress in the game.

Detailed Statistics of Game Elements: From the game state overview, gamification experts should be able to drill down to more detailed information on the relation between users and achievable game elements such as badges, levels, or missions. In particular, we define the following requirements:

(R10) User Distribution on Game Element State: Gamification experts should be able to gain insight about the distribution of users on the states of particular game elements. This should help them to understand how the users progress in context of the game element.

(R11) Temporal Statistics: Experts should be able to see how long users need for the completion of particular game elements.

(R12) User Characteristics: Gamification experts should be able to explore which statistically significant properties users have in common, who share the same state on a game element of interest. The game properties and user properties are distinguished. Game properties originate from the user's state in the game, e.g., owns badge A, while user properties originate from the information the application has about the user, e.g., from geographical region Europe. By revealing significant factors of user engagement in context of a particular game element, experts could optimize the game design for their individual audience.

(R21) User Interaction Tracking for Game Elements in the User Interface: The analytics should determine which effects the interaction with a game element has on user behavior, e.g., how viewing a leaderboard may influence the engagement of users.

(R22) Alerting: Half of the interviewed experts raised the requirement that they would

like to be alerted, when the statistics of a particular game element fulfill certain conditions.

- Gamification Design Adaptation

This category contains three requirements that are related to two aspects:"A/B Testing" and "Direct Design Adaptation".

A/B Testing: Tests with experimental and control groups (A/B tests) are a widely used method for evaluating the effects of changes in a particular context. Through A/B testing, the effects of game design changes can be verified before activating them for the whole user base. Thus, an integrated way of conducting experiments and analyzing their results could be one of the key features of gamification analytics. A/B testing comprises the following two requirements:

(R13) Experiment Creation: Experts should be able to create an experiment by defining its name, description, the size of the experimental group, target KPIs, desired KPI impact (increase or decrease), and the actual design changes which are subject of the experiment. After specifying the mentioned parameters and starting the experiment, a user group with the selected experiment size should start interacting with the new design. From this point on the analytics tool should analyze the difference between their behavior and the behavior of the rest of the users. This allows experts to analyze the generated impact.

(R14) Experiment Result Analysis: As an intermediate and final result of A/B tests, a gamification analytics tool should show the experts a summary of observed effects in user behavior. Moreover, it should indicate, whether the effects are statistically significant in comparison to the control group. This supports objective decision making in the design adaptation process. Experiment results should be archived for durable access to the result data which led to a design decision.

Direct Design Adaptation: Direct changes might be necessary in cases when A/B tests are not suitable, e.g., with small user groups or when time constraints apply:

(R15) Direct Design Adaptation: Gamification experts should also be able to conduct direct changes to the gamification design resulting in the creation of change markers in the KPI visualizations.

- User Groups of Interest

This category contains four requirements that are related to two aspects: "Definition of User Groups of Interest" and "Filtering of Overviews by User Groups of Interest". Experts should be able to focus their analyses on user groups which are of special interest.

Definition of User Groups of Interest: The following three techniques are relevant for the definition of user groups:

(R16) Criteria Based: The experts should be able to define groups based on criteria which are evaluated against the users' properties. This approach is applicable when the exact

criteria are well known before creating the user group. Such a group could, for instance, contain all users who are located in the geographical region Europe and who at the same time reached game level 9.

(R17) Cluster Analysis: Cluster Analysis aims at finding similar groups in a set of objects. The experts should be able to conduct a cluster analysis on relevant properties of users to discover groups which are of interest for them. This approach is applicable when the exact criteria of the user group are not known a priori.

(R18) Manual Selection: Experts should be able to manually compose a user group. This can be useful in the analysis of user groups, whose members' behavior is of special interest and whose members are known a priori. Gamification experts might, for instance, want to compose a user group out of community members with a high reputation. *Filtering of Overviews by User Groups of Interest:*

(R19) Filtering of Overviews by User Groups of Interest: The experts should be able to filter overviews by selecting a user group of interest. This should be possible at all places, where statistical overviews are shown.

- **Simulation**

(R20) Simulation: Gamification experts should be able to simulate their design ideas with existing user and behavior data. Given that an appropriate dataset of historical user behavior exists, a simulation can help to identify major flaws in the mechanics of a new gamification design. The simulation results should be explorable in the same way as real data by viewing application KPIs, game element analytics, and the opportunity of defining user groups of interest.

2.3 Gamified Learning Environments

According to Oluwajana et al., Gamified Learning Environment (GLE) is a process or an application of game mechanisms to the non-game environment to improve and motivate student learning behaviors (OLUWAJANA et al., 2019). In the Horizon Report of Higher Education 2017 (BECKER et al., 2017) was stated that gamification is one of the future forms of increasing students' engagement and participation in learning. The adoption of gamification to increase motivation is an essential practical application to assist educational stakeholders in creating a user-friendly learning environment that will meet educational needs (OLUWAJANA et al., 2019). Next, we will explore an example of a Gamified Learning Environment.

2.3.1 AVANCE

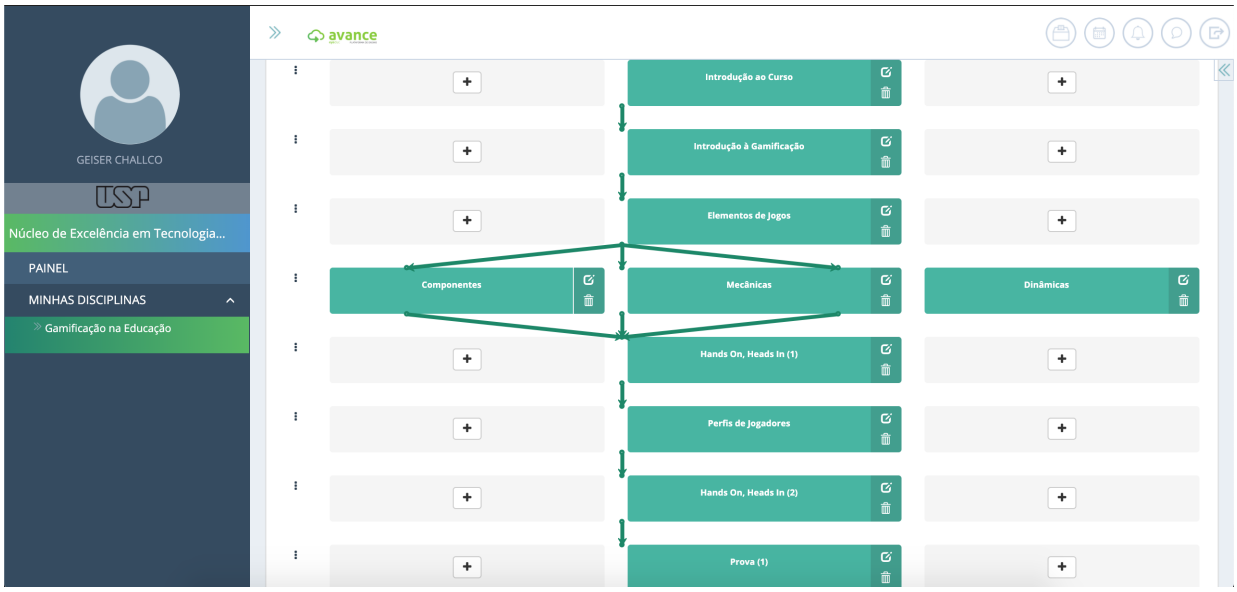
The educational system, Avance, is a gamified learning environment that is mainly composed by two modules, one for teachers and one for students [1]. In the following, both modules are described.

2.3.1.1 AVANCE-TEACHER

The first module provides an environment for teachers that enables them to:

-**Plan the course (see Fig. 3):** Teachers can create the knowledge tree, which will be the path that students will need to take to follow the course. In this step, teachers can change the path that students will take, as well as create and edit the topics and the relationships between them.

Figure 3 – AVANCE-TEACHER: Course's planning

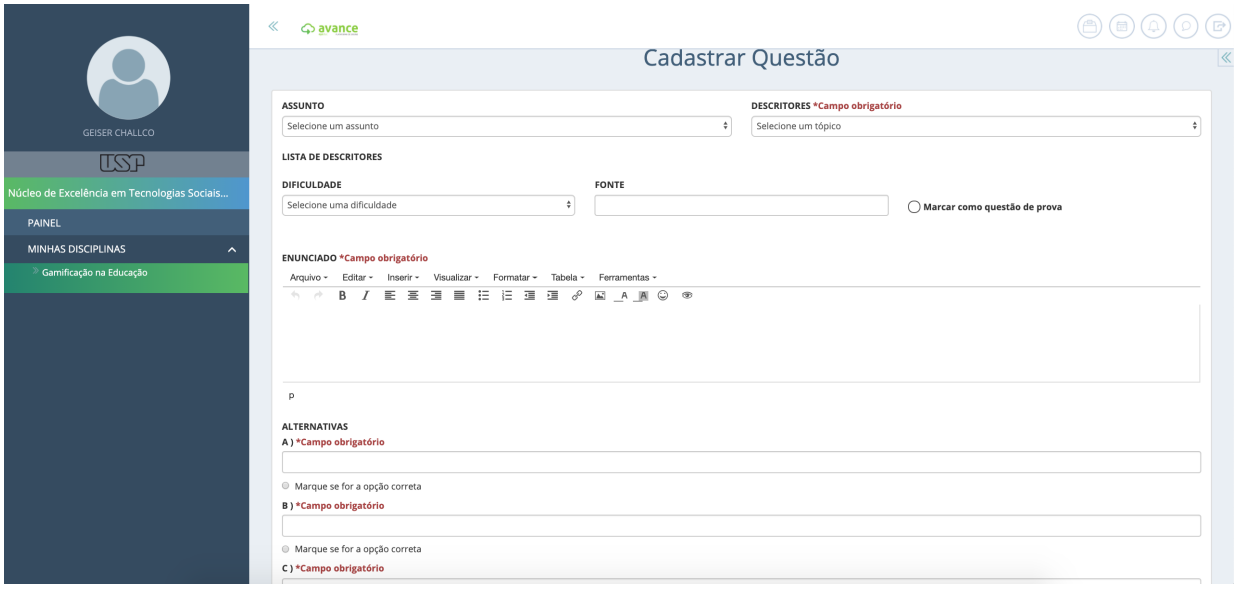


Picture Source: Avance Plataform. Available in: <avance.eyeduc.com>

-**Create or upload new learning resources (see Fig. 4):** For each topic, teachers can add content and create exercises. Contents that can be questions, PDF, Video, Link, forum, peer review.

1 <avance.eyeduc.com>

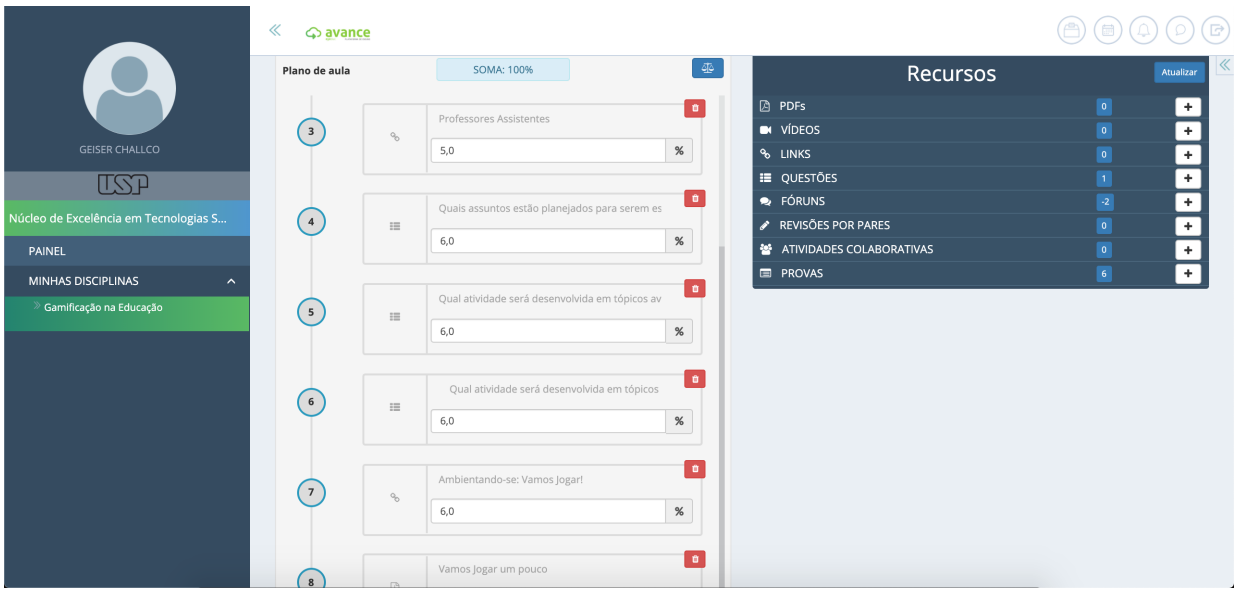
Figure 4 – **AVANCE-TEACHER: Creation of a new question**



Picture Source: Avance Plataform. Available in: <avance.eyeduc.com>

-Decide which resources students will interact to master each topic of the course (see Fig. 5): Teachers can register the instructional plan for each topic in a course. An instructional plan is the flow of resources that the student will need to spend to study a topic. On the registration page, teachers can insert the resources in the order that he wants the student to see.

Figure 5 – **AVANCE-TEACHER: Definition of instructional plan of each topic of the course**

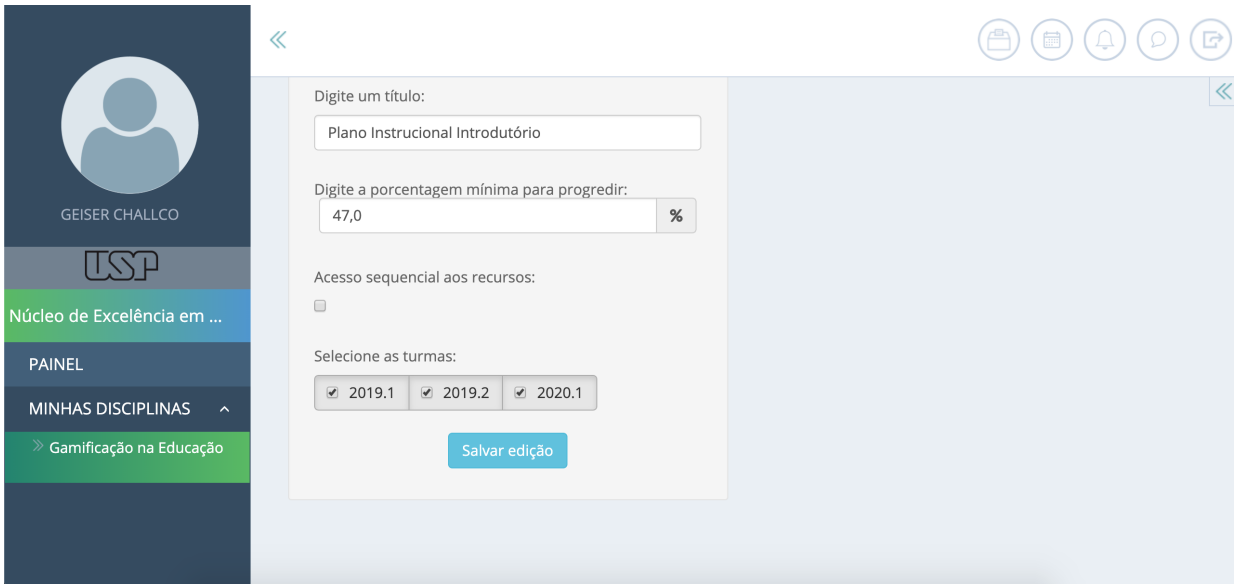


Picture Source: Avance Plataform. Available in: <avance.eyeduc.com>

-Define the expected interaction goals of each topic of the course (see Fig. 7 and Fig. 6): As explained in Section 4, the interaction goals can be represented by two

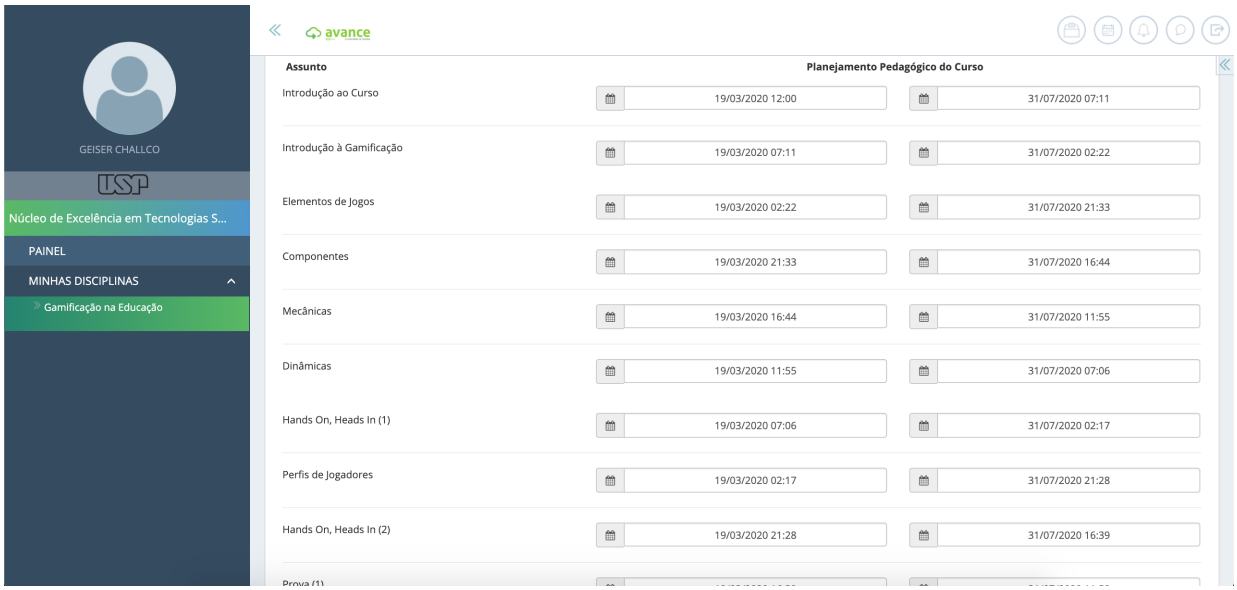
elements for each topic of the course (quantity of resources, and time expected). The quantity of resources represents the number of interactions expected students to interact with learning resources of a topic. When planning the instructional plan for each topic, the teacher must define the minimum percentage of interaction with the learning resources that students need to achieve in order to advance to the next topic in the knowledge tree. Moreover, teachers usually have a specific time programmed to teach each topic of a course. Teachers can edit the pedagogical planning of the course determining the expected period for students to master each topic of the course.

Figure 6 – AVANCE-TEACHER: Definition of the expected minimum percentage of students' interaction with the learning resources of each topic of the course



Picture Source: Avance Plataform. Available in: <avance.eyeduc.com>

Figure 7 – **AVANCE-TEACHER: Definition of the period expected that students domain each topic of the course**



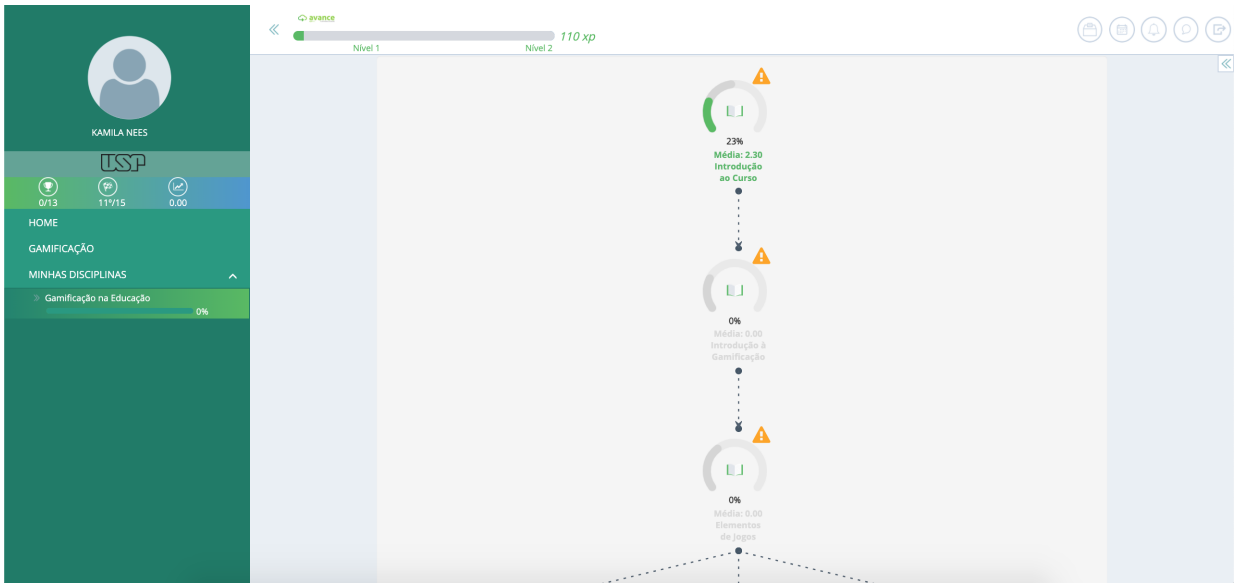
Picture Source: Avance Plataform. Available in: <avance.eyeduc.com>

2.3.1.2 AVANCE-STUDENTS

The second module supports students in the course's learning process. In this module, students can:

-**Access the course's plan made by teachers (See Fig. 8)**: The tree is the component that was defined by the teacher. The student will visualize all the topics of the course and will go through them according to their dependencies. The student must reach the minimum percentage (defined in the instructional plan by the teacher) to move on to the next topic. When completing all topics, students finish the course.

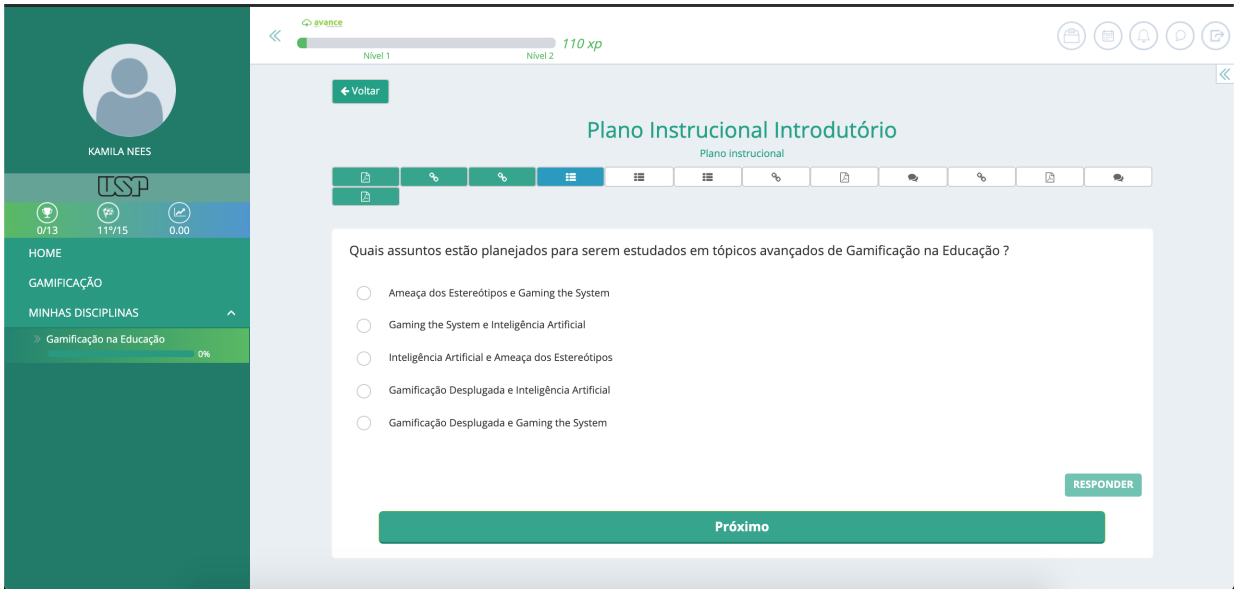
Figure 8 – **AVANCE-STUDENTS: Visualization of the knowledge tree assembled by the teacher for the course**



Picture Source: Avance Plataform. Available in: <avance.eyeduc.com>

-**Access the topics' instructional plan made by teachers and interact with the learning resources of each topic of the course (See Fig. 9)**: When the student clicks on a topic in the knowledge tree, it is redirected to the topic page. On this page, the student will see the resources that were registered by the teacher in the instructional plan. There is a flow of resources that students must follow - the plan can sequential or accessed in a random order; this is defined by the teacher.

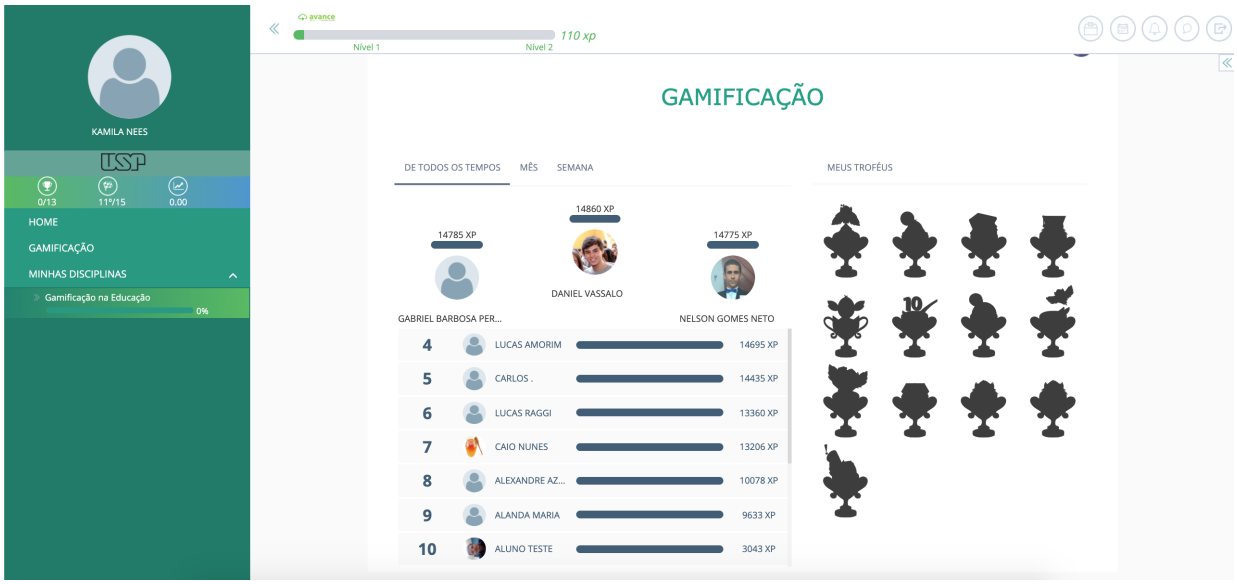
Figure 9 – **AVANCE-STUDENTS: Visualization and interaction with the learning resources that were registered by the teacher in the instructional plan**



Picture Source: Avance Plataform. Available in: <avance.eyeduc.com>

-Earn points, badges and increase level and position in the ranking interacting with the system (See Fig. 10): As a gamified educational environment, students may also earn points, badges and increase level and position in the ranking. The level and ranking is counted from the XP (points) that students earn when doing system activities.

Figure 10 – **AVANCE-STUDENTS: Student' level, earned trophies, points, and position in the class's ranking**



Picture Source: Avance Plataform. Available in: <avance.eyeduc.com>

3 STATE OF THE ART ANALYSIS

The objective of this chapter is to present the results of the state of the art analysis related to the topics addressed in this work. First, it will be presented and discussed a literature review found in the literature concerning the Gamification Analytics topic (See Section 3.1). Second, it will be presented and discussed a literature review conducted by the author of this dissertation concerning gamified learning environments (See Section 3.2).

3.1 Literature Review - Gamification Analytics

Trinidad, Calderón and Ruiz (TRINIDAD; CALDERÓN; RUIZ, 2018) conducted a systematic literature review aiming to investigate studies that focus on the monitoring process of gamification strategies. The SLR was performed following a predefined procedure that involves automatically searching in scientific digital databases (IEEE Xplore, ISI Web of Science, SpringerLink, ACM Digital Library and SCOPUS). The search string defined was the following boolean expression: ("gamification" AND "monitor"). 383 papers were found by the automatic searches in the digital databases and only 2 papers were selected as primary studies, according to the inclusion and exclusion criteria defined (See Fig. 11).

Figure 11 – **Inclusion/Exclusion criteria of the SLR by Trinidad, Calderón and Ruiz**

Table 2. Inclusion/Exclusion criteria

Inclusion criteria	• The retrieved study deals with the field of gamification monitoring process • The retrieved study introduces a tool for supporting the gamification monitoring process • The retrieved study adds value to the field of gamification monitoring process • The study is written in English
Exclusion criteria	• The retrieved study does not focus on gamification process • The retrieved study presents a specific application of gamification but does not deal with the gamification monitoring process • The retrieved study only has its abstract available and it is not possible to find its full-text • The retrieved study does not provide the required information clearly • The retrieved study is written in a language different from English • The retrieved study does not provide information included in other retrieved study or in other digital database (duplicates studies)

Picture source: Trinidad, Calderón and Ruiz (TRINIDAD; CALDERÓN; RUIZ, 2018)

3.1.1 Related Works

Considering the studies published by Herzig (HERZIG; AMELING; SCHILL, 2012) (HERZIG et al., 2015), the gamification process can mainly be summarized into the following four high-level phases: (i) Business modeling and Requirements; (ii) Design; (iii) Implementation;

(iv) Monitoring and Adaptation. However, only 2 studies that address the fourth phase were identified in the the SLR conducted by Trinidad, Calderón and Ruiz (TRINIDAD; CALDERÓN; RUIZ, 2018).

The two studies were: **"Tools for Gamification Analytics: A Survey" (HEILBRUNN; HERZIG; SCHILL, 2014a)** and **"MEdit4CEP-Gam: A model-driven approach for user-friendly gamification design, monitoring and code generation in CEP-based systems" (CALDERÓN; BOUBETA-PUIG; RUIZ, 2018)**. In "Tools for Gamification Analytics: A Survey" the focus is on the identification and assessment of relevant software solutions for gamification analytics domain as an important requirement of the gamification monitoring process. The second study, "MEdit4CEP-Gam: A model-driven approach for user-friendly gamification design, monitoring and code generation in CEP-based systems", proposes a tool based on Complex-Event Processing (CEP) and Model-Driven Engineering (MDE) technologies to support the design, implementation and monitoring of gamification strategies.

Both studies share similarities since both present tools for supporting the gamification process, both identify problems and needs regarding the gamification monitoring process and both assess the ability of the presented tools for supporting gamification experts with analytics. They also share the evaluation procedure which is based on the analysis of the coverage of the set of 22 requirements for gamification analytics tools provided by (HEILBRUNN; HERZIG; SCHILL, 2014a) (See Section 2).

Heilbrunn, Herzig and Schill (HEILBRUNN; HERZIG; SCHILL, 2014a) conducts a comparison of tools that support gamification analytics according to 22 requirements proposed by Heilbrunn, Herzig and Schill (HEILBRUNN; HERZIG; SCHILL, 2014b). After the proposal of the MEdit4CEP-Gam in (TRINIDAD; CALDERÓN; RUIZ, 2018), it was also conducted a comparison of the following tools (as seen in Figure 12) that support gamification analytics according to 22 requirements proposed by Heilbrunn, Herzig and Schill (HEILBRUNN; HERZIG; SCHILL, 2014b):

• MEdit4CEP-Gam: a tool developed at the University of Cadiz for supporting the gamification process that automates controlling and monitoring of gamification strategies on highly scalable and heterogeneous environments (CALDERÓN; BOUBETA-PUIG; RUIZ, 2018). It satisfies 10 out of 20 requirements for gamification analytics tools provided by Heilbrunn et al. (HEILBRUNN; HERZIG; SCHILL, 2014a).

• BunchBall: a commercial gamification platform that offers a set of pre-defined gamification-related reports and a user segmentation feature (HEILBRUNN; HERZIG; SCHILL, 2014a). It satisfies one out of 20 requirements for gamification analytics tools provided by Heilbrunn et al. (HEILBRUNN; HERZIG; SCHILL, 2014a).

• Gigya: a gamification platform whose target is the online communities. It offers

a set of predefined reports for social metrics (HEILBRUNN; HERZIG; SCHILL, 2014a). It satisfies one out of 20 requirements for gamification analytics tools provided by Heilbrunn et al. (HEILBRUNN; HERZIG; SCHILL, 2014a).

• The game analytics solutions DELTADNA, GAMEANALYTICS, GAMEHUD, HONEYTRACKS, and UPSIGHT mainly target monetization in F2P games. Accordingly, they come with a predefined set of event types and dashboards which are specialized to relevant metrics of the F2P domain. All tools provide interfaces to populate them with custom events. DELTADNA and GAMEHUD support arbitrary event structures. In GAMEANALYTICS, HONEYTRACKS, and UPSIGHT custom events have to comply with a pre-defined structure which means that they cannot be tailored to specific use cases (HEILBRUNN; HERZIG; SCHILL, 2014a).

Figure 12 – **Summary of the requirements supported by MEdit4CEP-Gam and other tools for gamification analytics**

	Requirement	MEdit4CEP-Gam	BUNCHBALL	GIGYA	DELTADNA	GAMEANALYTICS	GAMEHUD	HONEYTRACKS	UPSIGHT
Application KPI monitoring	R1: Definition of Custom KPIs	↑	↓	↓	↑	↗	↓	↘	↘
	R2: Definition of Pattern Based KPIs	↑	↓	↓	↓	↓	↓	↓	↓
	R3: Definition of KPI Goal Values	↑	↓	↓	↓	↓	↓	↓	↓
	R4: Dashboard	↓	↓	↓	↓	↑	↓	↗	↗
	R5: Change Markers	↓	↓	↓	↓	↓	↓	↑	↑
	R6: Goal Markers	↓	↓	↓	↓	↓	↓	↓	↓
Game Element Analytics	R7: Feedback Rate	↗	↓	↓	↗	↘	↘	↘	↘
	R8: Point Distributions	↗	↑	↓	↑	↓	↓	↓	↓
	R9: Achievable Game Elements Statistical Overview	↗	↓	↘	↗	↘	↘	↘	↘
	R10: User Distribution on Game Element State	↗	↓	↓	↓	↓	↓	↓	↓
	R11: Temporal Statistics	↗	↓	↓	↓	↓	↓	↓	↓
	R12: User Characteristics	↓	↓	↓	↓	↓	↓	↓	↓
	R21: User Interaction Tracking for Game Elements in the User Interface	↓	↓	↓	↓	↓	↓	↓	↓
	R22: Alerting	↗	↓	↓	↓	↓	↓	↓	↓
Gamification Design Adaptation	R13: Experiment Creation	↓	↓	↓	↘	↓	↓	↓	↓
	R14: Experiment Result Analysis	↓	↓	↓	↘	↘	↓	↘	↓
	R15: Direct Design Adaptation	↘	↓	↓	↓	↓	↓	↓	↓
User Groups of Interest	R16: Definition Based on Criteria	↓	↓	↓	↘	↘	↓	↘	↘
	R17: Definition Based on Cluster Analysis	↓	↓	↓	↘	↓	↓	↓	↓
	R18: Definition Based on Manual Selection	↓	↓	↓	↓	↓	↓	↓	↓
	R19: Filtering of Overviews by Users Groups	↓	↓	↓	↘	↘	↓	↘	↘
Simulation	R20: Simulation and Result Analysis	↓	↓	↓	↓	↓	↓	↓	↓
Number of Supported Requirement		**10**	**1**	**1**	**9**	**7**	**2**	**8**	**7**

↓ Not fulfilled, ↘ Partially fulfilled, ↗ Mostly fulfilled, ↑ Fulfilled

Picture source: Calderon, Boubeta-Puig, Ruiz (CALDERÓN; BOUBETA-PUIG; RUIZ, 2018)

As a conclusion, MEdit4CEP-Gam fulfills 10 out of the 22 requirements defined for assessing the quality of gamification monitoring support tools. The degree of fulfillment reached by this tool places it over the tools for gamification analytics analyzed in the survey reported in (HEILBRUNN; HERZIG; SCHILL, 2014a), in which the best tool (DELTADNA) achieved a partial or better support for 9 out of the 22 mentioned requirements.

3.1.2 Discussion

The tools discussed in (HEILBRUNN; HERZIG; SCHILL, 2014b) and (TRINIDAD; CALDERÓN; RUIZ, 2018) are general-purpose gamification platforms (TechnologyAdvice, 2019). According to Zichermann and Cunningham (ZICHERMANN; CUNNINGHAM, 2011), there are two main options to perform the implementation and to monitor the gamification strategies: (1) using a general-purpose gamification platform, or (2) creating self-built solutions for supporting gamification.

Table 1 – Comparison of MEdit4CEP-Gam and GamAnalytics Tool

	Requirements	MEdit4CEP-Gam	GamAnalytics Tool
Application KPI monitoring	R1: Definition of Custom KPIs	↑	↓
	R2: Definition of Pattern Based KPIs	↑	↓
	R3: Definition of KPI Goal Values	↑	↑
	R4: Dashboard	↓	↑
	R5: Change Markers	↓	↑
	R6: Goal Markers	↓	↑
Game Element Analytics	R7: Feedback Rate	↗	↓
	R8: Point Distributions	↗	↑
	R9: Achievable Game Elements Statistical Overview	↗	↑
	R10: User Distribution on Game Element State	↗	↑
	R11: Temporal Statistics	↗	↓
	R12: User Characteristics	↓	↓
	R21: User Interaction Tracking for Game Elements in the User Interface	↓	↗
	R22: Alerting	↗	↘
Gamification Design Adaptation	R13: Experiment Creation	↓	↗
	R14: Experiment Result Analysis	↓	↗
	R15: Direct Design Adaptation	↘	↑
User Groups of Interest	R16: Definition Based on Criteria	↓	↘
	R17: Definition Based on Cluster Analysis	↓	↓
	R18: Definition Based on Manual Selection	↓	↑
	R19: Filtering of Overviews by Users Groups	↓	↗
Simulation	R20: Simulation and Result Analysis	↓	↓
	Number of Supported Requirement	**10**	**13**
	$\downarrow Not fulfilled, \searrow Partially fulfilled, \nearrow Mostly fulfilled, \uparrow Fulfilled$		

The first option's platforms can be useful and an easier solution to gamify a system, site or process when the gamification process is not complex or when the developers do not have the knowledge or resources that are necessary to create a self-built solution (CALDERÓN; BOUBETA-PUIG; RUIZ, 2018). Nevertheless, the choose to use a generic gamification platform implies that the gamification strategy relies on the functionalities provided by the chosen platform, reducing the flexibility and interoperability with the system, involving high integration effort, leading to silo-based systems and limiting the game mechanics and the control of the gamification engine data (HERZIG; AMELING; SCHILL, 2012).

In contrast, the creation of self-built solutions to support gamification strategies (CALDERÓN; BOUBETA-PUIG; RUIZ, 2018) (MAICAN; LIXANDROIU; CONSTANTIN, 2016) allows users:

1. design tools that fit with their business goals;

2. have the control of the whole gamification engine;

3. provide the adequate resources in order to process, control and monitor the generated users' data.

Nonetheless, self-built solutions do not usually allow being reused because normally are designed and developed for a specific gamified system covering the requirements of strategy experts, challenging their integration in other contexts (CALDERÓN; BOUBETA-PUIG; RUIZ, 2018). Moreover, the creation of self-built solutions requires a high level of knowledge and understanding of gamification design and technologies to implement the necessary tools

(CALDERÓN; BOUBETA-PUIG; RUIZ, 2018).

Therefore, considering that the objective of this dissertation is to create a tool specifically for the educational domain, it would be more appropriate to develop a self-built solution to support gamification strategies of gamified learning environments. In Table 1, it is possible to visualize the comparison of MEdit4CEP-Gam (general-purpose gamification platform that most fulfilled the requirements) and GamAnalytics Tool (self-built tool proposed in this dissertation).

As seen, the GamAnalytics tool fulfills 13 out of the 22 requirements provided by (HEILBRUNN; HERZIG; SCHILL, 2014a). This result is superior to that achieved by the tool MEdit4CEP-Gam. Although the GamAnalytics tool was the technology that most fulfilled the requirements, the number of fulfilled requirements represents only 59% of the total. However, these results were already expected due to the fact that the target audience of the GamAnalytics tool is teachers and all the tools found in the literature previously evaluated according to the requirements provided by (HEILBRUNN; HERZIG; SCHILL, 2014a) had as the target audience the gamification experts. Therefore, there are some requirements that are not suited for teachers due to their complexity and were not considered in the GamAnaltytics tool.

3.2 Literature Review - Gamified Educational Learning Systems

3.2.1 Objective

The objective of this systematic literature review was to analyze studies that address gamification in adaptive learning systems and/or collaborative learning systems.

3.2.2 Research Questions

The research questions addressed in this systematic literature review are in line with the purpose of this dissertation and are the following:

RQ1: Do teachers have an authoring role in the presented studies' contributions?

RQ2: Is there monitoring and adaptation of gamification during the learning process?

RQ3: Is the teacher responsible for monitoring and adapting gamification during the learning process?

RQ4: Does the proposed solution allow teachers to monitor and adapt at the individual and class level?

3.2.3 Databases and Search String

Since the purpose of the SLR is to analyze studies that use gamification in collaborative learning and/or in adaptive learning studies, the resulting final search string was: ("collaborative learn- ing" OR "computer-supported collaborative learning" OR "coop- erative learning" OR "group learning" OR "team-based learn- ing" OR "adaptive learning" OR "intelligent education systems" OR "adaptive learning systems" OR "adaptive educational systems" OR "intelligent tutoring systems") AND "gamification".

The seven relevant academic databases in the computing area chosen to conduct the search were: *ACM Digital Library*[1], *AISeL*[2], *Elsevier*[3], *Engineering Village*[4], *IEEE Xplore*[5], *ISI Web of Science*[6] *e Scopus*[7]. The academic databases were chosen based on Chen, Babar, Zhang (CHEN; BABAR; ZHANG, 2010).

3.2.4 Inclusion and Exclusion Criteria

The following inclusion and exclusion criteria (Table 2 and 3, respectively) were defined. These criteria were used in the selection process in order to filter out the papers that are not aligned with the objective of this review.

Table 2 – Inclusion Criteria

Inclusion Criteria
Primary Studies
Peer-reviewed studies
Studies that address gamification in collaborative and/or adaptive learning scenarios

3.2.5 Search and Selection

The literature search was conducted from April to June 2018, resulting in 1228 papers. The results were automatically downloaded and were inserted into and organized with the aid of Parsifal tool [8]. In a first step, duplicated papers were automatically detected and removed using the Parsifal tool, remaining a total of 1007 papers. In the second step, the authors reviewed titles, keywords, abstracts and excluded those that were not related to the scope, according to the inclusion and exclusion criteria, remaining 96 papers. In the third step, each remaining

1 <http://dl.acm.org/>
2 <http://aisel.aisnet.org/>
3 <https://www.elsevier.com/>
4 <https://www.engineeringvillage.com/>
5 <http://ieeexplore.ieee.org/>
6 <http://www.isiknowledge.com>
7 <http://www.scopus.com>
8 <https://parsif.al/>

Table 3 – Exclusion Criteria

Exclusion Criteria
Secondary Studies
Non English written papers
Gray literature
Short-papers and Posters
Duplicated studies (only one copy of each study was included)
Redundant paper of same authorship
Studies not accessible
Non peer-reviewed studies
Studies that not address gamification in collaborative or adaptive learning scenarios

study was retrieved, completely analyzed and critically evaluated. The studies that did not meet predefined criteria were excluded, remaining a total of 41 studies selected.

3.2.6 Results

After applying the Inclusion and Exclusion criteria, 41 studies were selected for the final stage of the review. In this section we present the results of each research question and also give an overview of the general characteristics of the selected studies.

3.2.6.1 RQ1

A total of 22 out of 41 included studies provide teachers some authoring role in the presented contributions, as seen in Tables 4 and 5. Among these studies, it was identified studies that are concerned with offering students' data to assist teachers in the students' learning analysis and decision-making process. Some of these studies provide students' data without analysis, through reports or logs, to support teachers in conducting their own analysis, for instance, (MOCCOZET et al., 2013), (FU; CLARKE, 2016), (NAIK; KAMAT, 2015). However, some studies are concerned in processing, analyzing and displaying students' data in a meaningful way to assist teachers in the use of the system, based on research of information visualization, learning analytics and data mining, for instance, (GONZÁLEZ; TOLEDO; MUÑOZ, 2016), (LLORENS-LARGO et al., 2016), (PELED; SCHOCKEN, 2014), (PAIVA et al., 2016), (TENORIO et al., 2018).

In the following, it is presented an overview of each study whose teacher has some role of authoring in the proposed contribution. In (TENORIO et al., 2016), teachers can create the activities and the evaluation form that will be used by the students to review the activities done by their peers. Tenorio et al. (TENORIO et al., 2018) provides a web-based application that provides teachers with real-time support for classroom management, study group organization,

student enrollment, activity creation/publishing and report of students achievement about their individual/collective activities. In (REDONDO-DUARTE et al., 2017), teachers' roles include answering questions, providing feedback, conducting virtual classrooms and assessment rubrics. In (PAIVA; LEAL; QUEIRÓS, 2016), teachers can author and manage both exercises and content, as well as browse assessment results and student profiles. In the work by MUÑOZ et al (MUÑOZ et al., 2016), teachers make an initial approach for the collaborative activity, define learning objectives and evaluation criteria. They may also characterize students' profiles, develop collaborative learning processes, design the game strategies, and evaluate the collaboration. In (MOCCOZET et al., 2013), teachers can create a group for formal or informal learning activities, and in the study (FU; CLARKE, 2016), teachers can initialize the virtual points system for a course. (VEROY et al., 2016) allows instructors to post a question (a "prompt") to users respond, and (ORTEGA-ARRANZ et al., 2017) allows instructors to choose the students' actions that are gamified. In (RAMÍREZ-DONOSO et al., 2017), teachers can access and modify content in MOOCs, and, in (BORRAS-GENE; MARTINEZ-NUNEZ; BLANCO, 2016), teachers can create and manage virtual communities for their classrooms. In (PEDRO et al., 2015), teachers can create and integrate groups as well as can create, attribute and support badges. Moreover, teachers can prepare educational material in (THOMAS; BERKLING, 2013). In (BOTICKI et al., 2015), teachers are able to search, filter, sort data, and administer student groups or setup location-based prompts. (NAIK; KAMAT, 2015) provides an authoring tool that helps the faculty to put the content of the sessions in form of layers and screens to create a lesson, and to add the screens as random questions, standalone questions as well as in the form of question banks. In (DERMEVAL et al., 2017), teachers can configure a gamified ITS according to his preferences, defining the main elements (educational resources, curricula structure, game elements and so on). In (GONZÁLEZ; TOLEDO; MUÑOZ, 2016), teachers decide which tasks are presented to the student according to the learning objectives, and can manage users, groups and activities. In (KLOCK et al., 2015), teachers have the responsibility to provide the content of the course, and to evaluate the development of the learning. In (LLORENS-LARGO et al., 2016), teachers are capable of designing the learning activities, and, in (PELED; SCHOCKEN, 2014), teachers can control the selection and order in which the learning objects are presented to their students. In (FILIPCÍK; BIELIKOVÁ, 2014), teachers can choose some of the activities presented in the educational system and set them as preferred in order to motivate the students to perform these activities. In (SNOW et al., 2015), teachers can add their own texts that are not currently in the system and assign them to their students.

In the following, it is presented an overview of the studies that provide teachers with the students' information to assist them in the decision-making process. In (TENORIO et al., 2018), teachers can monitor, analyze and guide groups and individuals during the collective process of building knowledge, through a learning machinery. In (GONZÁLEZ; TOLEDO; MUÑOZ, 2016), the ITS presented includes a data visualization module where teachers can discover patterns in certain students learning difficulties based on the results of students activities. In

(LLORENS-LARGO et al., 2016), it is offered a progressive prediction system that transform real-time students interaction data into valuable information about students' progress, giving to teachers the ability of inducing student learning trends. In (PELED; SCHOCKEN, 2014), the data is continuously mined, summarized, and presented on the teacher's dashboard, as such, they can get real-time information about each child's current performance and their cumulative progress. In the (PAIVA et al., 2016) experiment, based on students interaction data, a spider-web graph was used to display the students weakest and strongest interactions to assist teachers/tutors in pedagogical decision-making. In addition, (DERMEVAL et al., 2017) proposes an architecture for developing gamified ITSs. In (DERMEVAL et al., 2017), there is a *Report* or-feature group representing the different types of reports that could be selected to be included in ITS products, but it has not been explained to which target audience these reports are targeted (e.g. teachers, students, etc.).

3.2.6.2 RQ2, RQ3 and RQ4

Two of the included studies (ANDRADE; MIZOGUCHI; ISOTANI, 2016) (PAIVA et al., 2016) proposes monitoring and adaptation of gamification during the learning process (RQ2) and only one proposes that teachers are responsible for this role (RQ3) (PAIVA et al., 2016). Any of the included studies proposed a solution that allow the teacher to monitor and adapt gamification at the individual and class level (RQ4).

Andrade, Mizoguchi and Isotani (ANDRADE; MIZOGUCHI; ISOTANI, 2016) proposes a framework that can offer the necessary infrastructure for ITS to personalize gamification (FIG) by monitoring students behavior, exploring how to best use game design elements and supporting "fading" mechanisms in order to avoid the negative effects caused by gamification. However, although the contribution of this work is concerning the monitoring and adaptation of gamification during the learning process in order to avoid the negative implications of gamification, teachers are not specifically pointed out as responsible for these tasks, unlike the proposal of this dissertation.

In (PAIVA et al., 2016), the main objective was to generate the students' interactional profile (according to students interactions in a gamified online learning environment), and present this information to teachers and tutors, who should use it to guide their pedagogical decision-making process. Based on students interaction data, spider-web graphs were used to display the students weakest and strongest interactions to assist teachers/tutors in pedagogical decision-making. The students' interactional profile were used to personalize gamification elements named missions.

The author of this work also published related works where the teachers' authoring of pedagogical decisions informed by data were investigated, (PAIVA et al., 2017) (PAIVA; BITTENCOURT, 2017) (PAIVA et al., 2019). These works are part of the author's doctoral thesis (PAIVA, 2017). The main focus of the thesis is MOOCs (Massive Open Online Courses)

where there are large number of dropouts and failures that students justify as lack of support. Based on it, the thesis proposes a technological solution that systematically supports teachers or tutors, from massive open online courses, to identify situations of pedagogical interest occurring with their students and to define how to approach such situations occurring with their (groups of) students.

The technological solution proposed, T-Partner, implemented the Pedagogical Decision Making Process. The Pedagogical Decision Making Process, also proposed in the thesis, is a cyclical process and uses educational data as its raw material, to detect pedagogical issues occurring within a learning environment; discover the patterns and trends associated to these issues, in favor of providing teachers and tutors relevant information to make good pedagogical decisions. Finally, the process monitors and evaluates whether the decisions were effective or not, comparing the students performance before and after being exposed to them.

In T-Partner (1) students' interactions with the integrated educational environment are stored (2) these data are obtained and processed by the T-Partner to (3) inform teachers/tutors about situations of pedagogical interest. (5) Based on this information, teachers and tutors create pedagogical decisions, which (6) will use educational resources and (7) the interface of the learning environment to (8) be sent to the target students.

The two experiments conducted in the thesis: (1) evaluate whether the process helps teachers and tutors to make useful and time-course pedagogical decisions; (2) to evaluate if the authoring solution guides the pedagogical decision making of teachers and tutors, suggest that the process brought benefits to pedagogical decision making and that the authoring solution T-Partner was able to guide the pedagogical decision making in course time and that its usefulness and ease of use were positively perceived by teachers and tutors.

3.2.7 Discussion

The objective of this section is to discuss the differences between the related works and this dissertation proposal. Considering that the focus of this dissertation is the monitoring and adaptation phase of gamification, the discussion will be focused in the study (PAIVA, 2017), which is the work most related to this dissertation. Therefore, although the focus of the Paiva's work (PAIVA, 2017) is not specifically gamified educational environments, the empirical research was conducted with data from students of a gamified MOOC, MeuTutor. Therefore, students' interaction with the learning resources and gamification elements of the system were considered to generate student interaction profiles and generate personalized missions to them depending on those profiles. Moreover, in the T-partner is provided for teachers, students' information concerning the interaction with system' resources and gamification elements, as is done in a similar way in the GamAnalytics tool, proposed in this dissertation proposal.

However, since the focus of the related work are MOOCs, and considering that MOOCs

have the capacity to support large amounts of learners interacting with the learning environment, in the solution presented teachers and tutors do not monitor each of their students, individually because it is not feasible for MOOCs. Therefore, in T-partner, students were grouped into three classes: inadequate condition, insufficient condition and condition proper, and the teacher could monitor data related to these groups, but not individually.

Consequently, the biggest difference of GamAnalytics tool and T-Partner is that GamAnalytics allows teachers to monitor and adapt both at the class level, at the group level, and at the individual level, allowing greater flexibility for teachers. Therefore, T-Partner may be the most suitable solution for very large classes that do not allow individual students' monitoring. While GamAnalytics may be the best solution for smaller classes, where it is feasible for teachers to monitor and provide individualized interventions.

In the Tables 4 and 5, it is possible to observe the difference between the selected study and the dissertation proposal.

Table 4 – Comparison of the related works and this dissertation proposed in relation to the research questions

Related Works	RQ1	RQ2	RQ3	RQ4
(TENORIO et al., 2016)	Yes	No	No	No
(TENORIO et al., 2018)	Yes	No	No	No
(JACKOVÁ; DENNY, 2015)	No	No	No	No
(KNUTAS et al., 2016)	No	No	No	No
(REDONDO-DUARTE et al., 2017)	Yes	No	No	No
(CARO-ALVARO et al., 2017)	No	No	No	No
(USAMI et al., 2015)	No	No	No	No
(WANG et al., 2016)	No	No	No	No
(PAIVA; LEAL; QUEIRÓS, 2016)	Yes	No	No	No
(MUÑOZ et al., 2016)	Yes	No	No	No
(CHALLCO et al., 2016)	No	No	No	No
(MOCCOZET et al., 2013)	Yes	No	No	No
(FU; CLARKE, 2016)	Yes	No	No	No
(VEROY et al., 2016)	Yes	No	No	No
(ORTEGA-ARRANZ et al., 2017)	Yes	No	No	No
(RAMÍREZ-DONOSO et al., 2017)	Yes	No	No	No
(BORRAS-GENE; MARTINEZ-NUNEZ; BLANCO, 2016)	Yes	No	No	No
(PEDRO et al., 2015)	Yes	No	No	No

Table 5 – Comparison of the related works and this dissertation proposed in relation to the research questions

Related Works	RQ1	RQ2	RQ3	RQ4
(KNUTAS et al., 2017)	No	No	No	No
(THOMAS; BERKLING, 2013)	Yes	No	No	No
(PONTI, 2015)	No	No	No	No
(LATULIPE; LONG; SEMINARIO, 2015)	No	No	No	No
(BORGES et al., 2016)	No	No	No	No
(RAMAKRISNAN; JAAFAR, 2016)	No	No	No	No
(BOTICKI et al., 2015)	Yes	No	No	No
(SANTANA et al., 2016)	No	No	No	No
(MONTERRAT; LAVOUÉ; GEORGE, 2017)	No	No	No	No
(NAIK; KAMAT, 2015)	Yes	No	No	No
(ZATARAIN-CABADA; BARRÓN-ESTRADA; RÍOS-FÉLIX, 2017)	No	No	No	No
(DERMEVAL et al., 2017)	Yes	No	No	No
(KIFOR, 2017)	No	No	No	No
(UTOMO; SANTOSO, 2015)	No	No	No	No
(GONZÁLEZ; TOLEDO; MUÑOZ, 2016)	Yes	No	No	No
(KLOCK et al., 2015)	Yes	No	No	No
(LLORENS-LARGO et al., 2016)	Yes	No	No	No
(PELED; SCHOCKEN, 2014)	Yes	No	No	No
(FILIPCÍK; BIELIKOVÁ, 2014)	Yes	No	No	No
(SNOW et al., 2015)	Yes	No	No	No
(SHI; CRISTEA, 2016)	No	No	No	No
(ANDRADE; MIZOGUCHI; ISOTANI, 2016)	No	Yes	No	No
(PAIVA, 2017)	Yes	Yes	Yes	No
Dissertation proposal	Yes	Yes	Yes	Yes

4 MODEL PROPOSAL

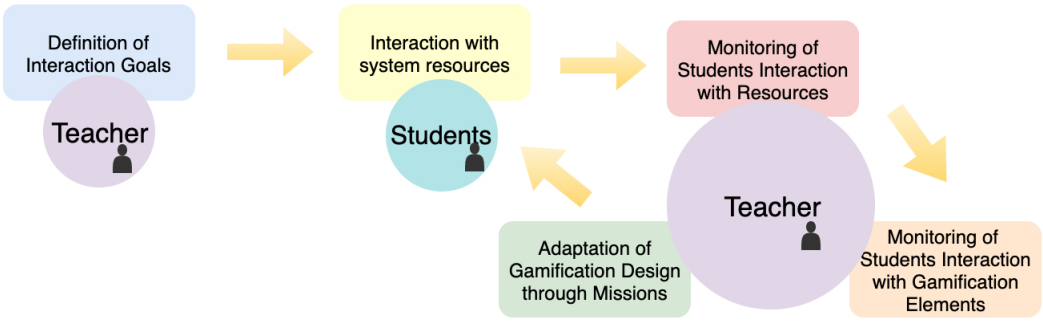
The proposal of this dissertation is to present a gamification analytics model for teachers, aiming to facilitate the monitoring and adaptation of gamification design during the learning process of gamified learning environments by teachers. Based on this model, teachers can monitor and adapt the gamification design, increasing the chances of positively impacting students' engagement, learning. and motivation.

4.1 Gamification Analytics Model for Teachers

Considering that the target audience of the solution proposed in this dissertation are teachers, the main focus is to present a simple, intuitive and usable model. However, in order to implement the model that are being proposed here, it is essential that the gamification design of the gamified educational system be previously well planned using some gamification model or framework consolidated in the literature, such as 6D framework (WERBACH; HUNTER, 2012), Octalysis framework (CHOU, 2015), GAFCC model (HUANG; HEW, 2018). Furthermore, it is also necessary consider the possible design adaptations during learning process that will be made by teachers. This planning in advance is important to facilitate later use by teachers.

The Gamification Analytics Model for Teachers was based on the presented theoretical model of user requirements for supporting the monitoring and adaptation of gamification designs proposed by Heilbrunn, Herzig and Schill (HEILBRUNN; HERZIG; SCHILL, 2014b). However, the concepts that compose the model were adapted considering the target audience of the model (i.e. teachers) and results reported in the computers and education research field. Each concept that composes the model will be explained in the following subsections, and the overview of the proposed model in this dissertation can be seen in Figure 13.

Figure 13 – **Gamification Analytics Model for Teachers**



Picture Source: Author

4.1.1 Definition of Interaction Goals

Considering the importance, of defining clear business goals and measuring the success of gamification designs towards their achievement, as emphasized by Gamification literature (HEILBRUNN; HERZIG; SCHILL, 2014b) (HUANG; HEW, 2018) (WERBACH; HUNTER, 2012), in the Gamification Analytics Model for Teachers, teachers can define interaction goals that they expect students achieve in a given period of time. The interaction goals can be represented by two elements for each topic (quantity of resources, time expected). Resources are the elements available in the educational system that support students' learning (e.g videos, texts, questionnaires, forum). Therefore, the quantity of resources represents a number of interactions that is expected that students have with learning resources of a topic. Moreover, teachers usually have a specific time programmed to teach each topic of a study domain. Therefore, it is also necessary to determine the time in the interaction goals. The interaction goals serve as metric for teachers in the monitoring phase because they will be able to assess whether the class/student is far or not from the interaction goal defined, checking if students are in the expected pace. Furthermore, teachers also will be able to verify the impact of gamification on the achievement of those goals. For instance, one interaction goal configured by a teacher can be: expect that students solve at least 30 questionnaires about a specific topic in 2 weeks.

4.1.2 Monitoring of students‘ interaction with learning resources

In the Gamification Analytics Model for Teachers, teachers are allowed to visualize students‘ interaction with learning resources available in the gamified learning system, and compare if the students interactions are as planned to achieve the interaction goals defined by the teacher. The interaction goals defined previously can serve as metric during the learning process for teachers in the monitoring phase because they are able to assess whether the class is far or not from the interaction goal defined, checking if the student is at the expected pace. In order to better provide these important data for teachers, it is necessary to rely on research in Information Visualization and Learning Dashboards. The positive effects of Information Visualization and Learning Dashboards on teachers' decision-making processes in the technology-enhanced learning context have been reported in studies in the literature (PAIVA; BITTENCOURT, 2017) (MOLENAAR; CAMPEN, 2017) (XHAKAJ; ALEVEN; MCLAREN, 2017) (LEEUWEN, 2015). Learning dashboards can inform teachers via time graphs, charts, and descriptive statistics, and it will allow teachers to investigate either the students' interaction and the impact of gamification over time.

4.1.3 Monitoring of Students' Interaction with Gamification Elements

There are different objectives in showing students' interaction with gamification elements to the teachers. First, teachers can visualize students' interactions with the gamification elements

implemented in the system in order to understand students‘ engagement wiith these elements, increasing teachers awareness about students‘ status. Moreover, this monitoring could increase the chance of teachers perceiving the positive impact of gamification, and hence, motivating themselves towards the use of gamification. Second, as can be seen in Figure 13, the adaptation of the gamification design during the learning process is performed by using the gamification element mission, thus, it is necessary that teachers can visualize which missions are more effective to motivate the students. Through these visualizations, teachers could see which missions were most successful, and assign missions properly along the learning process. This concept is based on the theoretical model of user requirements for supporting the monitoring and adaptation of gamification designs proposed by Heilbrunn, Herzig and Schill (HEILBRUNN; HERZIG; SCHILL, 2014b). However, there is a lack of studies that explore the effects of the visualization of students' interaction with gamification elements in the technology-enhanced learning context.

4.1.4 Adaptation of Gamification Design through Missions

As previously explained, the adaptation of gamification design in educational system are made by teachers through the gamification element mission if they judge necessary, e.g. when the students interaction is decreasing over time and they are not achieving the interaction goal defined by the teacher. In previous studies, the use of missions to motivate students during the learning process proved to be an effective approach (PAIVA et al., 2016) (PAIVA; BITTENCOURT, 2017). Therefore, we propose the usage of missions to adapt gamification design during the learning process because when teachers perceive students interactions are not as expected, they can assign missions in order to motivate students to interact more with the educational resources available in the system. Hence, the gamification design of other gamification elements will also be adapted because when students achieve a mission, they also conquer points, badges, level, and change their position on the leaderboard. Depending on the system that implements the model, teachers can choose pre-defined missions previously implemented in the educational system or teachers can customize missions according to their preferences.

4.2 Application of the Gamification Analytics Model for Teachers in E-Learning Systems - Illustrative Scenario

In this section, we aim to demonstrate an illustrative scenario to describe how the model proposed can be executed in a real scenario. The initial basic function of teachers who adopts an e-learning system is to prepare the system for their students to use. Therefore, teachers need

to define the domain and the specific topics that aims students learn. After that, depending on the e-learning system chosen, teachers can add resources that they expect students interact related to certain topic, or visualize the resources already existent in the system related to the chosen topic. Subsequently, the system is ready to be used by students.

As explained earlier, due to the problems of motivation that students have been experiencing during the use of e-learning systems, the application of gamification has been increasing as an approach to engage students to use these systems. However, although positive learning results have been reported through the use of gamification, studies that report unexpected outcomes are also found in the literature. One of the possible causes of these negative results is the lack of monitoring and adaptation of the gamification design, considering that the design is not a rigid artifact.

The Gamification Analytics Model proposed here enables teachers monitor students‘ interaction with learning resources and gamification elements and also enables teacher adapt/intervene in the gamification design during learning process. Based on it, after the common procedure of e-learning systems, explained before, gamified e-learning systems can include the model proposed in this dissertation. An illustrative process can be seen in Figure 14

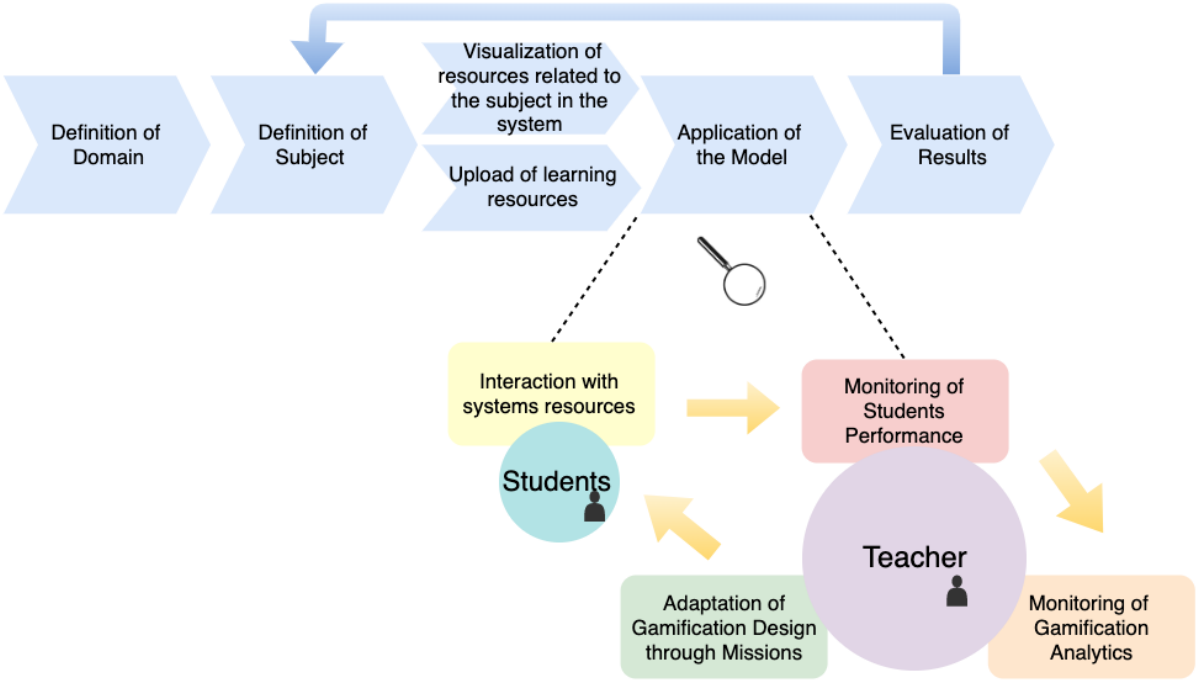
Normally, teachers are the actors responsible for the pedagogical planning of the course they teach, including the choice of educational resources (e.g. videos, texts, questionnaires, forums) and the estimated time for the domain of each topic that is part of the course. Based on it, teachers during the learning process expect that students interact with the educational resources related to a topic in a specific time programmed.

Therefore, in the gamified learning systems where the gamification analytics model will be implemented, during the pedagogical planning (besides the definition of the curricula structure of the course and the educational resources) teachers are able to define interaction goals for each topic. For example, considering a course of 6 weeks (e.g. fundamentals of math course) with 3 topics (e.g. decimals, exponents, fractions), for each topic, teachers could define as interaction goal that students should interact with 80% of the educational resources related to each topic in two weeks to consider they have learned the topics.

After the pedagogical planning, students will be able to interact with the educational system, and teachers could use the interaction goals defined for each topic as a metric to evaluate whether students are at the expected pace or are not achieving the defined goals. To support the understanding of the teachers about the learning state of the class, teachers will be able to monitor students' interaction with the educational resources (e.g. the interaction of each student with the educational resources, i.e., interacted with success, interacted with no success, not interacted, the progress of students concerning the interaction with the resources over time) and the gamification elements available in the educational system (e.g., how many points each student accumulated so far, students' ranking and current level).

However, in case teachers perceive that some students are not at the expected pace, teachers could assign missions to motivate, engage students to achieve the interaction goals at the expected time. For example, two days left until the end of the second week of the fundamental of math course, the teacher realizes that only 60% of the class achieved the interaction goals for the first topic (decimals), so the teacher can assign a mission for the students that did not achieve the interaction goals (e.g., teacher can choose two videos and three questionnaires that some students did not interact yet, and offer a reward, for instance, points, or currency) for the students that interact with these resources in one day). Therefore, teachers could motivate/engage these students to achieve the 80% of the interaction with the educational resources of the decimals topic until the end of second week.

Figure 14 – **Application of the Gamification Analytics Model for Teachers in E-learning Environments**



Picture Source: Author

5 DESIGN CONCEPTS BASED ON THE GAMIFICATION ANALYTICS MODEL FOR TEACHERS

The objective of this chapter is to explain the speed dating method that was conducted to validate design concepts with teachers that could be implemented in systems that adopt the proposed gamification analytics model.

5.1 Validation through Speed Dating method

In order to explore the wide range of feature possibilities with users, the speed dating method based on the HCI (Human-Computer Interaction) research is designed to help researchers/designers draw unmet needs and probe the boundaries of what certain users will find acceptable (initially unknown until a technology prototype)g (HOLSTEIN; MCLAREN; ALEVEN, 2017) (ZIMMERMAN; FORLIZZI, 2017). The method begins with sessions in which participants receive hypothetical scenarios in rapid succession (for example, through storyboards) while researchers observe and understand participants' immediate reactions (DAVIDOFF et al., 2007) (ODOM et al., 2012) (ZIMMERMAN; FORLIZZI, 2017). The Speed Dating method leads to the discovery of unexpected design opportunities when unforeseen needs are found, based on participants' assessment of the given scenario. It is important to highlight that the Speed Dating method can reveal needs and opportunities not easily discovered through field observations or other project activities (DAVIDOFF et al., 2007) (ZIMMERMAN; FORLIZZI, 2017) (DILLAHUNT et al., 2018) (ODOM et al., 2012).

This method consists of two main stages - validation and user approval. In the validation step, researchers present to the target users a variety of predefined storyboards to observe the needs that users demonstrate (DAVIDOFF et al., 2007) (TRUONG; HAYES; ABOWD, 2006). Storyboards select innovation spaces and use this information to narrow the design space for the potential product. Therefore, researchers create an array of critical design problems and write short dramatic scenarios that address the permutations of these problems. As such, participants must play a specific role that they play regularly (as a teacher) while running through scenarios in a simulation (demonstrated by storyboards) (DAVIDOFF et al., 2007) (BUCHENAU; SURI, 2000) (TRUONG; HAYES; ABOWD, 2006).

5.2 Validation of design concepts based on the Gamification Analytics Model for Teachers

As the gamification analytics model for teachers is a new contribution, it is still an open question how to design gamified educational systems that will implement this model in the future. Therefore, it is of utmost importance that model-based design concepts are well designed to respect the needs of the teachers. Hence, the "Speed Dating method" was used to validate the design concepts related to the gamification analytics model for teachers. As the target audience of the model are teachers, we recruited 15 teachers to participate in individual sessions, through emails or requests made personally, 14 post-secondary teachers and 1 secondary education teacher, all living in the State of Alagoas, Brazil. The duration of the sessions with each teacher ranged from 30 to 60 minutes and 14 were performed at the Federal University of Alagoas and 1 through videoconference (with the help of meet.google.com).

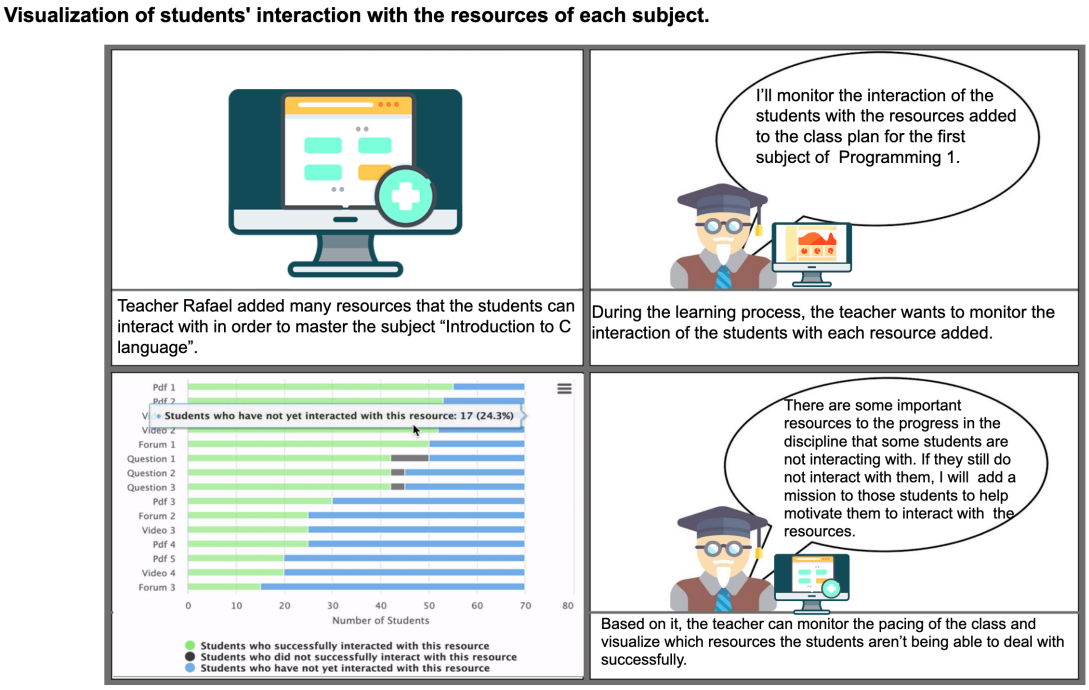
At the beginning of each session, teachers attended a presentation made by one of the researchers, where teachers were presented with a contextualization of learning systems, gamification, and their challenges. Afterward, the "monitoring and adaptation model for gamification design for teachers" proposed was presented. Moreover, to put all teachers at the same page regarding their understanding of gamified educational environments, the "Avance" gamified educational platform [1] and its functionalities were introduced, clarifying doubts that appeared from teachers about educational environments and gamification. Therefore, it was possible to equalize the knowledge level of all teachers, so they could formulate a more concrete opinion on the subject in the evaluation of the concepts embedded in the storyboards.

The session participants were introduced to design concepts based on the model proposed through storyboards (e.g. see Figure 15). Teachers had time to read, reflect, and analyze each concept presented. At this time, teachers were encouraged to talk about their immediate reactions to the concept presented. Hence, the teachers evaluated the concept and classified it into three grades: grade 1 (if the teacher thought the concept would be relevant for him to use in a gamified educational environment), grade -1 (if the teacher thought the concept would not be relevant for him to use in a gamified educational environment) and grade 0 (if the teacher could not decide whether or not the concept would be relevant to him). These grades are based on the work by Holstein, MacLaren and Aleven (HOLSTEIN; MCLAREN; ALEVEN, 2019).

The first design concepts presented to teachers were developed by the author of the model. However, teachers could at any time suggest new ideas for the formulation of new concepts based on their needs. When a teacher suggested a new concept, the researchers created a new storyboard related to the concept and that storyboard would be included in the set shown to the next participant. After debating and evaluating a concept, the next concept

[1] <https://avance.eyeduc.com/>

Figure 15 – Storyboard of the concept 7



Picture Source: Author

was presented, extending that method until the last concept in the set. During this process, two supporting researchers were responsible for recording teachers' opinions, ideas, and grades for each concept for future analysis.

This research was initialized with 13 initial concepts, which were increased after the suggestion of new concepts by the teachers, resulting in a maximum of 20 concepts until the end of the research. After conducting the analysis, a table was created with the average teacher evaluation for each concept presented and recorded opinions of each teacher. The information given by each teacher will be further analyzed, so researchers can define what will be developed or adjusted in future gamified learning platforms.

5.3 Speed Dating Results

As previously explained, 20 design concepts based on the gamification analytics model proposed in this dissertation were evaluated by teachers in order to understand their needs in gamified learning systems. These concepts are related to the visualizations they judge most applicable to monitor students' interaction with resources and students' interaction with gamification elements, as well as the most appropriate procedures for adapting gamification design when deemed necessary. In this section, we discuss the most seven well-rated design concepts in 5.3.1 and most three poorly rated design concepts in 5.3.2. The list of all design concepts and their correspondent storyboards explored in this work can be visualized either in the following GoogleSite (translated into the English language): sites.google.com or in the

Figure 16 – Validation results and average

Concepts	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	T15	Average
Concept 1	1	1	1	1	1	1	-1	1	1	1	1	1	1	1	-1	0,7333333333
Concept 2	1	1	1	0	1	-1	0	-1	1	1	1	1	1	1	1	0,6
Concept 3	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	0,9333333333
Concept 4	1	1	0	1	-1	0	1	1	0	1	1	1	1	1	1	0,6666666667
Concept 5	1	1	1	1	1	1	-1	1	1	-1	1	0	0	1	1	0,6
Concept 6	1	1	0	1	0	1	0	1	-1	-1	1	0	-1	1	-1	0,2
Concept 7	1	1	1	1	-1	1	-1	-1	1	1	1	1	1	1	1	0,6
Concept 8	1	1	1	1	0	1	1	1	1	1	1	1	1	1	1	0,9333333333
Concept 9	1	-1	1	1	1	1	1	1	1	1	1	1	1	1	1	0,8666666667
Concept 10	1	1	0	1	1	0	1	1	1	-1	1	1	0	1	1	0,6666666667
Concept 11	1	1	1	1	1	0	1	0	1	1	1	1	1	1	1	0,8666666667
Concept 12	1	1	1	0	1	0	0	1	1	1	1	1	1	1	1	0,8
Concept 13	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Concept 14		1	1	1	1	1	1	1	1	-1	1	0	1	1	1	0,7857142857
Concept 15		1	1	1	1	0	1	1	0	-1	1	1	0	1	1	0,6428571429
Concept 16		1	1	1	0	1	-1	1	-1	-1	-1	0	0	1	1	0,2142857143
Concept 17				1	1	-1	1	1	1	1	1	1	1	1	1	0,8333333333
Concept 18				1	1	0	1	0	0	1	1	1	1	1	1	0,75
Concept 19					-1	-1	-1	1	1	-1	1	1	1	1	1	0,2727272727
Concept 20					1	1	-1	-1	1	1	1	1	1	1	1	0,6363636364

Picture Source: Author

Appendix A (Original storyboards - Portuguese language).

The quantitative evaluation made by teachers about each design concept can be visualized in Figure 54. The columns in this figure represent the teachers who participated in the research (listed in order of participation), and the rows represent the design concepts. The last seven design concepts listed in the figure were generated by the participants. The cells in red indicate that the teacher evaluated negatively the correspondent concept while the cells in yellow indicate that the teacher was neutral about the correspondent concept. Moreover, the cells in green show that the teacher rated positively the correspondent design concept. The overall average rating of the design concepts among teachers is listed in the rightmost column. The average was calculated considering the sum of the grades the teachers assigned to the design concept divided by the number of teachers who evaluated the following design concept.

5.3.1 Most well-rated design concepts

Concept 1: *Definition of interaction goals (Average: 0,7333333333)*

Most of the interviewed teachers agreed that the platform should provide autonomy for the teacher to define the interaction goals that students are expected to achieve in a topic, such as, defining the minimum percentage of interaction with the learning resources that students must achieve and the period foreseen for this interaction occurs. As stated by teacher T2 and T12, these defined goals help students to organize themselves and have clarity about the teacher's goals. However, teacher T15 stated that "perhaps time is not necessary, as it is a mechanism that puts pressure on the student".

Concept 2: *Visualization of the class' progress over time (Average: 0,6)*

Regarding concept 2, most teachers thought it relevant to be able to visualize the average interaction of the class with the resources of each topic over time and compare it with the interaction goal defined by the teacher. Teachers T2 and T3 opined that this visualization will help the teacher in the development of his methodology and helps him to identify any demotivation of the class and may act by interfering. However, teacher T8 stated that " monitoring the daily evolution can be a problem, due to the lack of time/availability of the teacher".

Concept 3: *Visualization of the percentage of the students that reached interaction goals (Average: 0,9333333333)*

The vast majority of participants reported that this concept is fundamental to understand the progress of the class, enabling the teacher to intervene and make a decision regarding these results (T1, T2, T4, T9, T15), since the purpose of the concept is to provide a visualization in the system showing how many of the students have already reached the interaction goals defined by the teacher. As pointed out by teacher T9, "This visualization is important for a quick overview of the class as we would know if we can move on to the next topic, or continue in the topic and intervene in the process to motivate students to achieve the goals".

Concept 4: *Visualization of the class' descriptive data (Average: 0,6666666667)*

Teachers also well assessed the concept of the teacher being able to view class data descriptively in the system, rather than just charts. However, most teachers stressed that this type of visualization should be used in conjunction with the charts, and not replace them.

Concept 5: *Visualization of the class' distribution over the levels (Average: 0,6)*

This concept is related to the gamification of the system, to the concept of levels derived from gamification. Based on this concept, teachers can visualize the distribution of students at different levels. For some teachers (T6, T14, T11), this visualization could be used for teachers graphically (quickly) see the class progress. However, teacher T7 stated that "the levels are superficial, they can generate certain prejudices against some groups, and they may feel inferior".

Concept 7: *Visualization of the class' interaction with the resources (Average: 0,6)*

Teachers rated concept 7 well, they consider it relevant for teachers to see the number of students' interaction with the learning resources added to the activity plan for each topic. Teacher T3 pointed out that "this concept would be relevant to know what resources students have difficulty interacting on each subject".

Concept 8: *Visualization of each student's interaction with the resources (Average: 0,9333333333)*

From the opinions captured in the sessions regarding this concept, we realize the need

for the teacher to obtain a detailed view of each student, not just the class, and visualize their interaction with each available resource in the system (T2, T9, T15). Therefore, this concept enables the teacher to visualize the interaction of each student with each resource added in the activity plan of each topic. However, some teachers reported that for classes with a small number of students this concept would be ideal, but for large classes would be impracticable (T5, T10).

Concept 9: *Creation of personalized missions for a student or for a specific group (Average: 0,8666666667)*

In this concept we noted the need for the teacher to have autonomy to intervene / adapt the system when the state of the students or a specific student is not as expected. The mission, in the teachers' view, makes it possible to motivate students to interact with the system resources and motivate the achievement of interaction goals (T1, T3, T6, T13). Some teachers believe that missions can have a more positive impact if they involve rewards that impact students' grades (T1, T6). In addition, one teacher reported, "The teacher could monitor groups by levels and could select from the most advanced group to assist the less advanced students as well, being possible to create a mission with this suggestion" (T2). In addition, by analyzing other points of view, we obtained negative opinions regarding the offering of rewards (such as trophy, points) to students who achieve a mission. As reported by teacher T15, the reward would be the learning.

Concept 10: *Creation of missions for all students in the class (Average: 0,8666666667)*

Most teachers positively rated this concept. This concept is related to the intervention that the teacher can make in the system when the class status in general is not as expected. The mission is the possibility to motivate the class to interact with the system resources. However, teacher T10 stated that "that these missions will be useful for some, but not for others. I think it would be regressive".

Concept 11: *Show the status of each mission created (Average: 0,8666666667)*

This concept was considered relevant by most of the teachers who participated in the sessions. For teachers, once missions are created, it is important for them to be able to view the results of each mission they create, such as the number of students who successfully completed the mission, the number of students who tried but did not achieve the mission, and the students who have not tried. Teachers believe this visualization becomes interesting for teacher monitoring and evaluation of which assignments have the most positive impact on students (T12) and whether they are positively impacting students' level of interaction with resources (T9). From a teacher's view, with this concept he can measure the difficulty of the mission, whether it is difficult, easy or moderate. It also has the possibility to look for students who failed the mission to know the reasons for the failure (T1).

Concept 12: *Show the impact of each mission on the class' overall interaction (Average:*

0,8)

This concept is related to the teacher being able to visualize the increase of the average percentage of class interaction with resources after the creation of a mission. According to some teachers, it is important to have an overview of the impact of the mission on the class in general (T1, T2, T11). However, some teachers did not agree, as one teacher approached, "It would be interesting to show by groups, not for the whole class" (T5). In addition, another teacher pointed out that "this view is shallow because it measures only one metric and may cause unexpected problems for the teacher" (T10).

***Concept 13**: Help button provided for each visualization describing its functionality (Average: 1)*

This concept was the most well-rated among the teachers who participated in the sessions. For teachers, the support of the system through help buttons describing the functionality of the graphics is important especially at the beginning of the teacher's interaction with the system when the teacher is not familiar with the system (T14, T11, T3). In addition, this functionality increases the possibility of joining users with few technological experiences (T1, T9).

***Concept 14:** Visualization of student's levels (Average: 0,7857142857)*

Most teachers positively rated this concept. This concept is related to the teacher being able to visualize which students are at each level in the educational system. T13 stated that "it is important to level the class, considering that knowing the name of the student who is late it is possible to intervene more effectively in the class and in each student". However, teacher T5 stated that "depends on the size of the class, if the class is large, it is not relevant".

***Concept 15:** Visualization of each student's interaction with missions (Average: 0,6428571429)*

This concept was considered relevant by most of the teachers who participated in the sessions. This concept is related to teachers being able to visualize which of their students successfully achieved the mission, which ones tried but did not achieve the mission and which did not attempt. However, teacher T5 stated that "depends on the size of the class, if the class is large, it is not relevant".

***Concept 17**: Visualization of student's progress over time (Average: 0,8333333333)*

This concept was accepted as important by most teachers who participated in the sessions and is related to the visualization of the progress of the student interaction percentage with the resources daily. As pointed out by some teachers (T8, T9), this visualization "allows a better visualization if the student is struggling or not, if he is engaged or not". However, one teacher (T6) stated "I prefer to focus on students' points and level rather than the overall progress".

Concept 18: *Show the impact of each mission on the student's interaction percentage (Average: 0,75)*

This concept was accepted as important by most teachers who participated in the sessions, and it is related to the teacher being able to visualize the impact of each mission created on the percentage of student interaction with resources.

Concept 20: *Creation of missions for high performing students (Average: 0,6363636364)*

Teachers rated concept 20 well. This concept is related to the teacher having the autonomy to create missions for students who already have a high level of interaction with the system's learning resources. These missions would be a way to reward these students, while giving the opportunity for students to further expand their knowledge of the topic. Teacher T10 stated that these mission "it would serve as a motivation, giving a challenge to advanced students without disturbing those who are not at that level".

5.3.2 Most poorly rated design concepts

Concept 6*: Visualization of the number of students who achieved each trophy (Average: 0,2)*

Some teachers see the possibility of taking advantage of this concept, given that the trophies obtained by the students correspond to the achievements and facilities in the use of the system, "can be used to compare the evolution of the class through the trophies" (T2) and "interesting to analyze the motivation or difficulty of the class with the trophies "(T4). However, the concept was poorly evaluated by most teachers, because according to teachers T3, T5, T9, T10, T13, T14, this functionality would not affect the methodology applied by the teacher. As pointed out by professor T10, "This kind of visualization would be most useful for designers or teachers with full control of course authorship, but apart from this use it can be a problem than a solution."

Concept 16*: Visualization of each student's interaction with the trophies (Average: 0,2142857143)*

The purpose of this concept is to visualize each student's trophy achievements. However, the teachers show doubts regarding the achievement of trophies and their relationship with student performance, "I do not find the viewing of trophies per student as relevant", says the teacher (T11). Moreover, the teacher T3 affirms the relevance of this concept, "being a way to track students' performance".

Concept 19*:Visualization of student's descriptive data (Average: 0,2727272727)*

The availability of student descriptive data (interaction with resources, trophies, missions completed) for teachers in a textual way was poorly rated due to the teachers' remarkable preference for visualizing data through graphs. For teacher T10, "presentation as the text may

be a detriment to the teacher, a sensory noise."

5.4 Discussion

The future gamified learning systems that will adopt the "Gamification Analytics Model for Teachers" need to implement model-based design concepts in the system that correspond to teachers' needs. Therefore, in order to validate these design concepts, we used the "Speed Dating" method to understand the teachers' needs in gamified learning systems. It was discussed the most well-rated design concepts and most poorly rated design concepts related to the "Gamification Analytics Model for Teachers". In general, most of the 20 design concepts evaluated by the participant teachers were well accepted and judged useful.

The most well-rated concept was the concept 13 (Help button provided for each visualization describing its functionality), teachers pointed out that this functionality is mainly important at the beginning of teachers' interaction with the system, supporting and facilitating the understanding of the visualizations provided in the gamified learning systems. Others highly well-rated concepts designs were the concepts 3 (Visualization of the percentage of the students that reached interaction goals) and 8 (Visualization of each student interaction with the resources). Note that the there was a high acceptance rate for both more general, class level visualizations (such as concepts 2, 3, 5, 7, 11), and the more specific, more individually focused visualizations (such as concepts 8, 14, 15, 17). The first type of visualization helps the teacher because it is a very compact and straightforward visualization while the second type of visualization helps the teacher to act in isolated cases in the underperforming students, as stated by teacher T3.

Furthermore, the most poorly rated design concept was concept 6 (Visualization of the number of students who achieved each trophy), followed by concept 16 (Visualization of each student's interaction with the trophies) and concept 19 (Visualization of student descriptive data). Therefore, it could be observed that the visualization of the interaction of students with the trophies available in the gamified learning system was not judged important and relevant by the teachers. However, the students' interaction with others gamification elements as missions and levels (concepts 5, 11, 14, 15) were well-rated design concepts. Consequently, although teachers did not evaluate the visualization of the interaction of students with the trophies relevant, teachers judged useful/relevant visualize students' interaction with others gamification elements (missions, levels) to help them understand the students' status.

Teachers have also demonstrated that visualizing students' data through graphs is more relevant for them than visualizing students' data through descriptive data in a textual way. During the speed dating process, some teachers highlighted how better is to visualize students' data through graphs. For example, teacher T9 stated that visualize students' interaction through descriptive data could be relevant, but visualize through graphs is more enjoyable and useful.

Teachers T2 and T6 concluded that both visualizations could be relevant, but they should not be shown together, but by demand, at different levels.

6 GAMANALYTICS TOOL FOR TEACHERS

In this chapter, the implementation of the Gamification Analytics Model for Teacher is explained in a computational point of view through the development of the GamAnalytics tool. The GamAnalytics tool has been integrated into a Gamified Learning Environment, named Avance[1] (see Subsection 2.3.1)). Therefore, in the following Section 6.1 is going to be presented the implementation process, the integration with the Avance environment, and the final result of the gamification analytics model-based tool.

6.1 GamAnalytics Tool

As explained before, this dissertation proposes a gamification analytics model for teachers. In order to better design a tool with respect to the needs and limits of teachers, the most well rated design concepts in the "speed dating method", described in Section 5, were included in the gamification analytics model-based tool's prototype. In a first step, a prototype was developed using the Figma collaborative interface design tool[2]. After feedback of some researchers of the "Computers and Education" research field, a final prototype was achieved[3]. As was intended to connect the developed tool to the Avance platform, the design style of the tool is similar to Avance to facilitate teachers' interaction and avoid confusion.

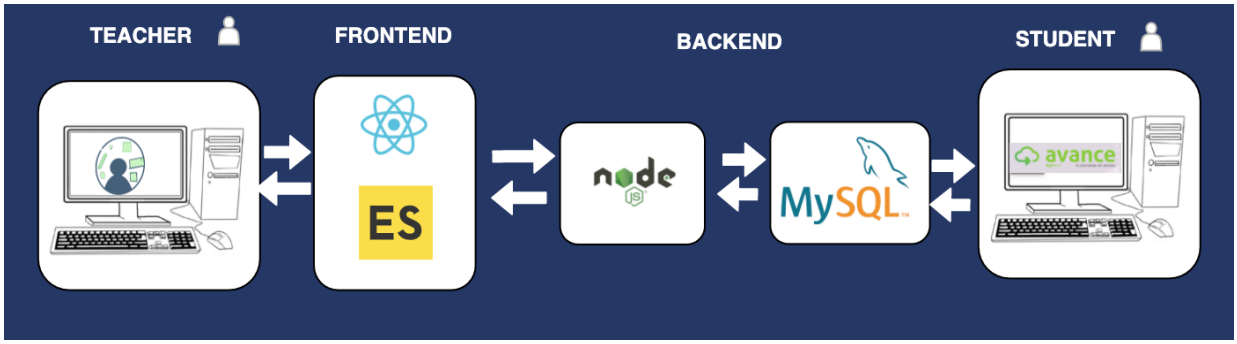
The GamAnalytics tool was implemented using the following technologies, as seen in the Fig. 17. To implement the front-end of the web-based tool, the JavaScript library, named React [4], was chosen. This is a declarative, efficient, and flexible library. The reason for choosing React is due to the Virtual DOM of React, taking into consideration that the tool is highly interactive and demands fast changes according to teachers' requests, it is possible to manage each of these changing states easily and dynamically presenting the content to teachers in an acceptable time of operation.

For the server-side, Node.js, an open-source and cross-platform JavaScript runtime environment[5] was used. Moreover, the Express framework was adopted [6]. This is a minimal and flexible Node.js web application framework that provides a robust set of features for web and mobile applications, making it easy to develop an application which can be used to handle multiple types of users' requests. Furthermore, considering that Avance makes use of

1 <avance.eyeduc.com>
2 <https://www.figma.com/>
3 Final prototypes are available at https://www.figma.com/prototype
4 <https://reactjs.org/>
5 <https://nodejs.dev/>
6 <https://expressjs.com/>

MySQL database, the Sequelize, a Node.js ORM, was used to facilitate the management of the database, and retrieve all the necessary data that tool would make use of the Avance platform.

Figure 17 – **Development of the gamification analytics model-based tool's prototype**



Picture Source: Author

In Fig. 18, it is possible to visualize the Use Case Diagram of the GamAnalytics tool. The functionalities offered to the teachers in the GamAnalitycs tool, represented in the Use Case Diagram, will be explained below at the same time that the tool screens are presented.

After the teacher is logged in the tool (See Fig. 19), he/she can choose which course will be monitored (See Fig. 20). After the course's selection, it is possible to monitor the interaction of the whole class (Class Dashboard - See Fig. 21) or each student of the class (Student's Dashboard - See. Fig. 27) with learning resources and gamification elements.

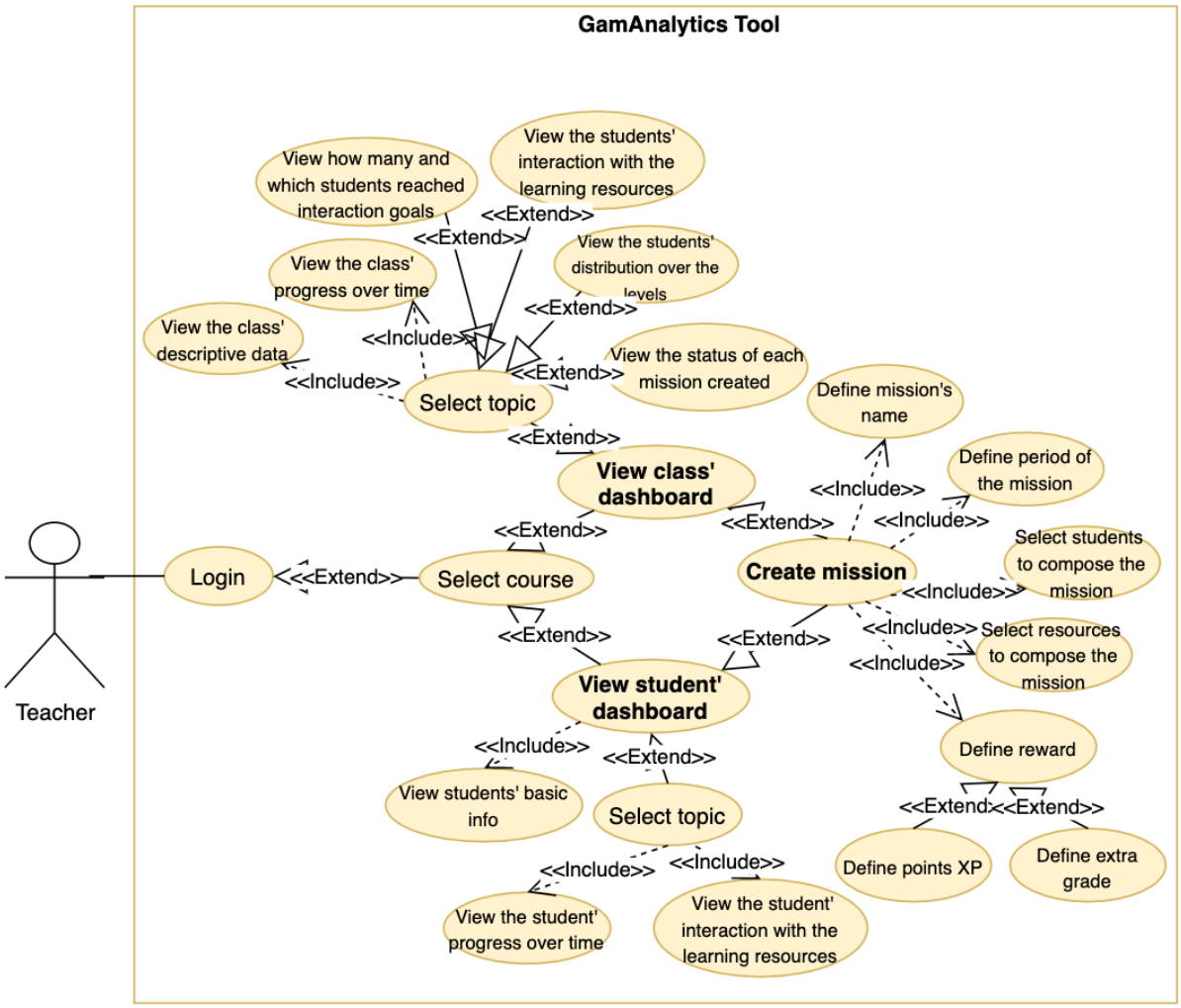
In the Class Dashboard, for each topic of the course selected (teachers can select it in the tool), the following design concepts were introduced:

-Visualization of the class' descriptive data (See Fig. 21): In the class dashboard, teachers can visualize in a descriptive way how many students are registered in the class, the period expected for students to master the chosen topic, and how many students achieved the interaction goal of the topic.

-Visualization of the class' progress over time (See Fig. 22): In the class dashboard, there is a time chart where teachers can visualize the class's progress over time concerning the interaction with learning resources. It is also possible to visualize the minimum needed percentage that students should achieve in order to advance to the next topic. This indication serves as metrics for teachers, comparing the average progress of the class with what is expected in relation to the interaction goal of the referred topic. Furthermore, teachers can visualize the impact of the created missions on the overall average of the class's progress in order to assess whether they are causing any positive impacts. The period expected for students to master the chosen topic is also showed in this time graph.

-Visualization of the percentage of the students that reached interaction goals (See Fig. 23): In the class dashboard, there is a bar chart that indicates the number

Figure 18 – **GAMANALYTICS: Use Case Diagram**



Picture Source: Author

and percentage of students who reached and did not reach the interaction goals defined by the teacher for that topic. This allows the teacher to quickly visualize the distribution of students.

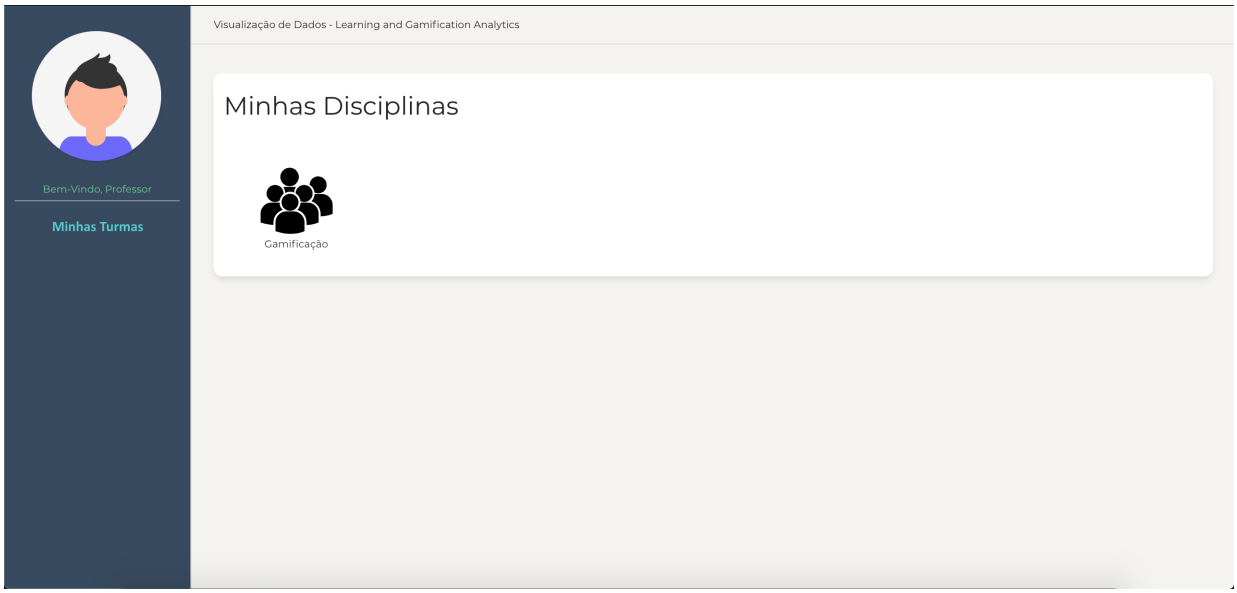
-**Visualization of the list of students‘ names who reached and who did not reach the interaction goals (See Fig. 23):** In the class dashboard, below the bar chart that shows the percentage of the students that reached interaction goals, there is a navigation bar where it is possible to visualize the list of students‘ names who reached and who did not reach the interaction goals defined by the teacher. In this way, it is possible for teachers to quickly understand who are the students who need more attention, and make more personalized interventions.

-**Visualization of the class’ interaction with the learning resources (See Fig. 24):** In the class dashboard, there is a bar chart showing how many students interacted successfully, did not interact successfully and did not attempt to interact with each learning resource on that topic. This makes it possible to see the level of interaction of students with

Figure 19 – **GAMANALYTICS: Login Page**

Picture Source: Author

Figure 20 – **GAMANALYTICS: Courses to which the logged-in teacher is linked**

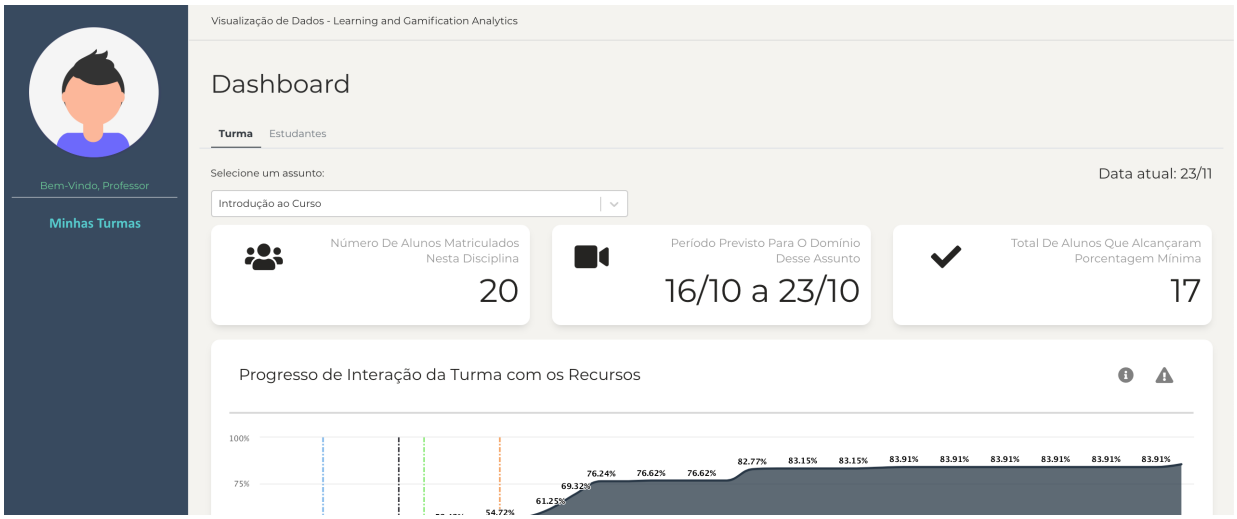


Picture Source: Author

each resource and to understand which resources students are interacting less and having more difficulty with.

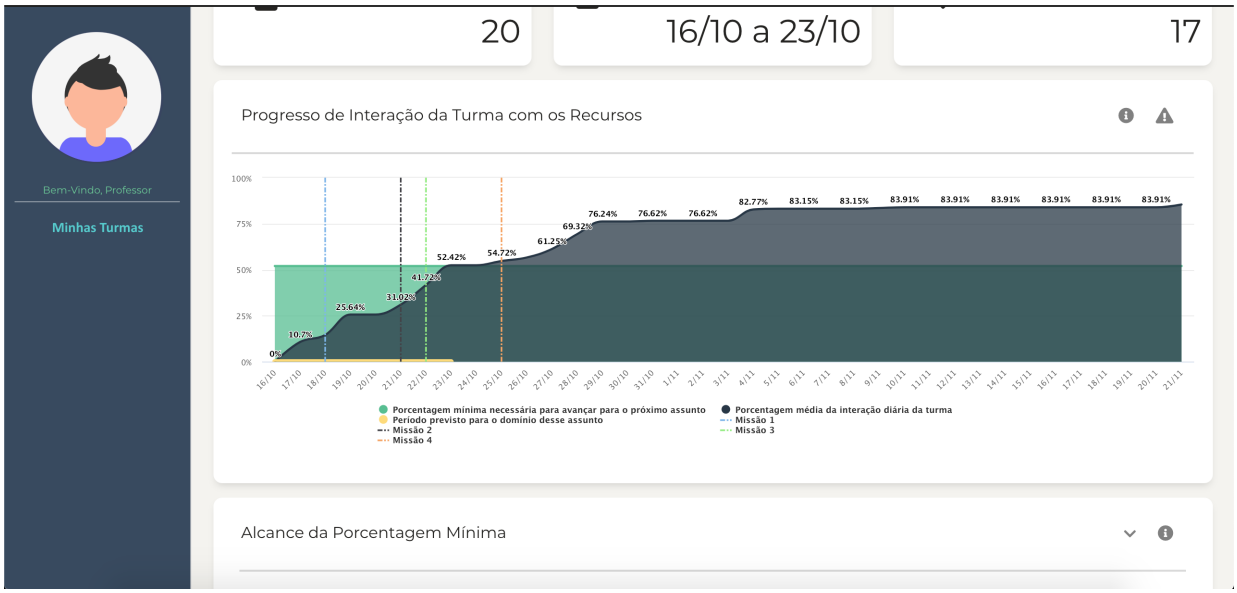
-**Visualization of each student's interaction with the learning resources of the chosen topic (See Fig. 24):** In the class dashboard,below the bar chart that indicates the class's interaction with learning resources, teachers can view a table showing the interaction of each student with each learning resource for the chosen topic, indicating who were the students that interacted successfully, did not interact successfully and did not attempt to interact with each learning resource on that topic. This visualization can allow the teacher to quickly understand which students are more advanced and performing better and which

Figure 21 – **GAMANALYTICS: Class Dashboard - Visualization of the class' descriptive data**



Picture Source: Author

Figure 22 – **GAMANALYTICS: Class Dashboard - Visualization of the class' progress over time**



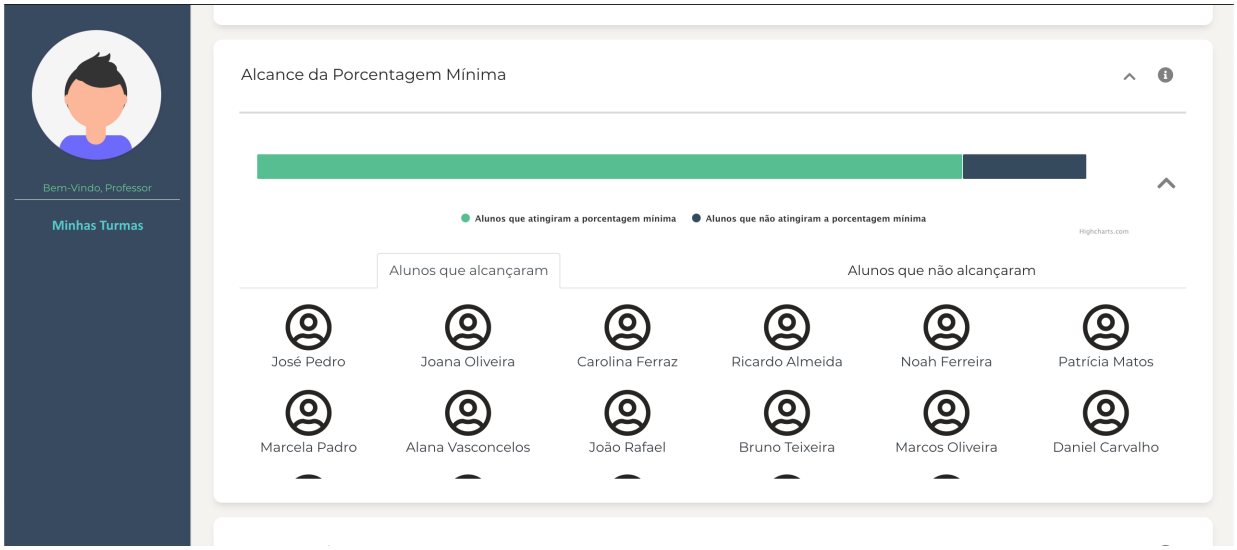
Picture Source: Author

students are not getting the expected results, and make more personalized interventions.

-**Visualization of the class' distribution over the levels (See Fig. 25)**: In the class dashboard, there is a bar chart that shows the number of students that is at each level of gamification in the gamified educational environment. This visualization helps teachers to quickly visualize the distribution of the students in the gamification levels and to understand if the students are dispersed (in different rhythms) or concentrated (in similar rhythms).

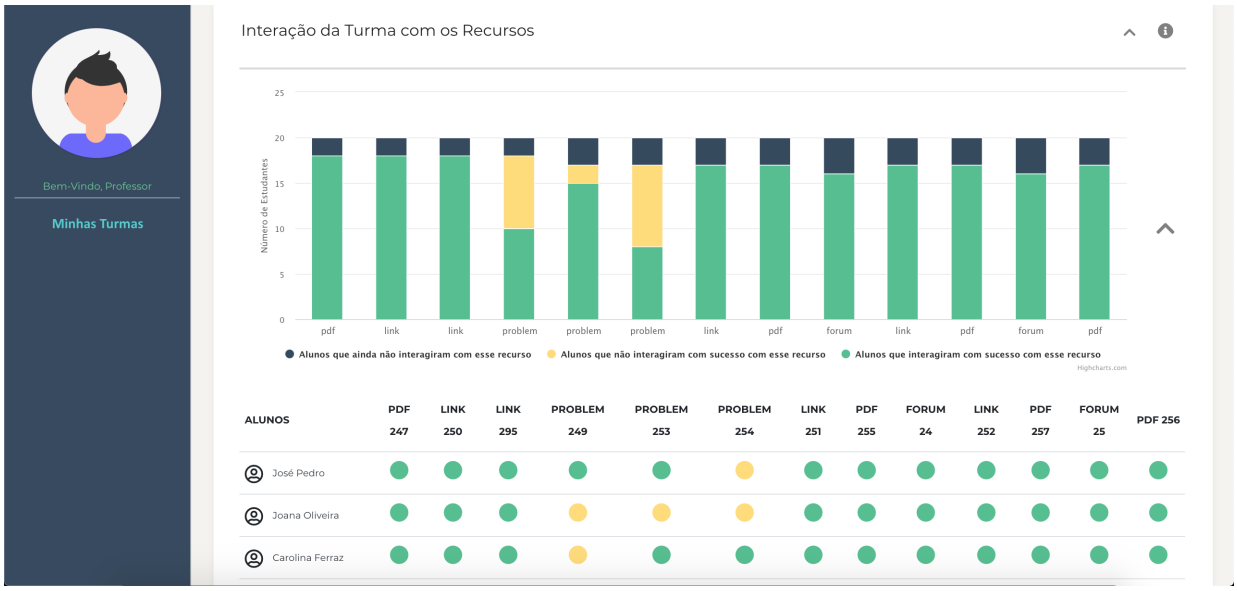
-**Visualization of each student's levels (See Fig. 25)**: In the class dashboard, below the chart that shows class' distribution over the levels, there is a navigation bar that

Figure 23 – **GAMANALYTICS: Class Dashboard - Visualization of the percentage of the students that reached interaction goals and the list of students' names who reached and who did not reach the interaction goals**



Picture Source: Author

Figure 24 – **GAMANALYTICS: Class Dashboard - Visualization of the class' interaction with the learning resources and visualization of each student's interaction with the learning resources of the chosen topic**

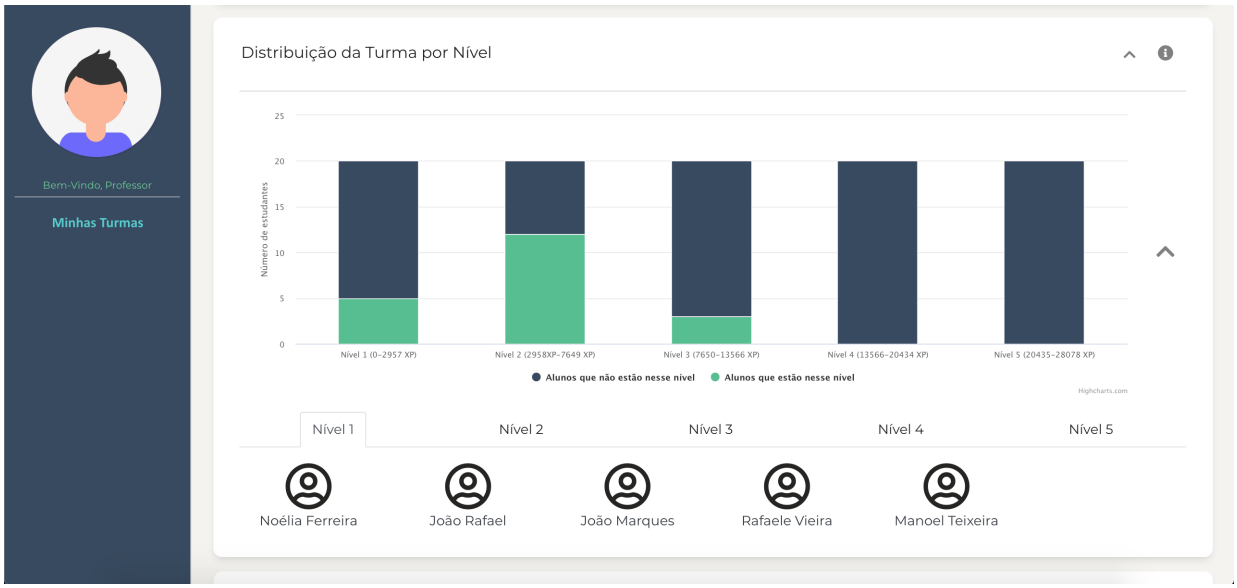


Picture Source: Author

allows the teacher to see which students are at each level of gamification in the educational environment. This allows the teacher to have a more detailed view, and allows teachers to make more personalized interventions to students who are not getting the expected results.

-**Visualization of the status of each mission created by teachers (See Fig. 26):** In the class dashboard, there is a bar chart that shows the number of students that achieved, did not achieve and did not attempt to achieve each mission created by the teacher in

Figure 25 – **GAMANALYTICS: Class Dashboard - Visualization of the class' distribution over the levels and visualization of each student's levels**



Picture Source: Author

the referred topic. From this, teachers can quickly visualize which missions were most successful, which missions are difficult for students to achieve, which missions did not motivate students as expected. In this way, teachers can infer which rewards used in the missions aroused the most interest from the students, which resources were best interacted in the missions.

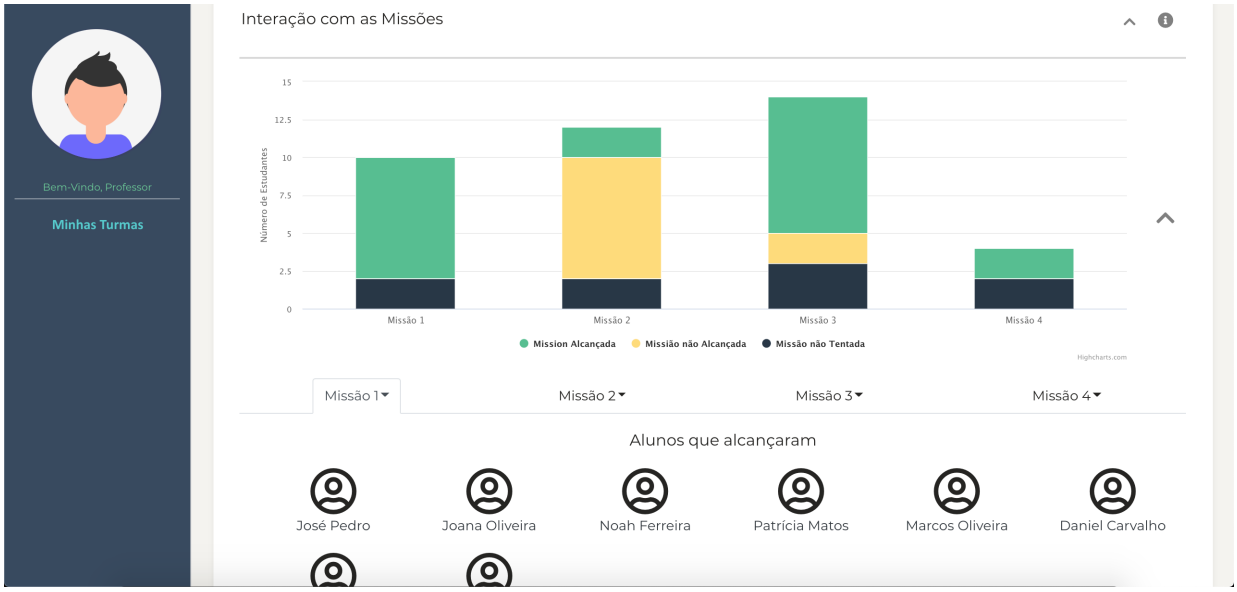
-Visualization of each student's interaction with the created missions (See Fig. 26): In the class dashboard, below the chart that shows the status of each mission created, there is a navigation bar that makes it possible, for each mission, to visualize the names of the students who achieved, did not achieve and did not attempt to achieve the mission. This allows the teacher to have a more detailed view, and allows teachers to make more personalized interventions to students who are not getting the expected results.

Moreover, teacher can also visualize each student's dashboard. In the GamAnalytics tool, there is a list of all students enrolled in the referred course (See Fig. 27). Therefore, teachers can select the student that wants to monitor.

At the beginning of the student's dashboard, there is basic information about him, such as name, email, XP score, and current gamification level. This visualization aims to provide a quick overview of the student to the teacher (See Fig. 28). In the Student's Dashboard, for each topic of the course selected (teachers can select it in the tool), the following design concepts were introduced:

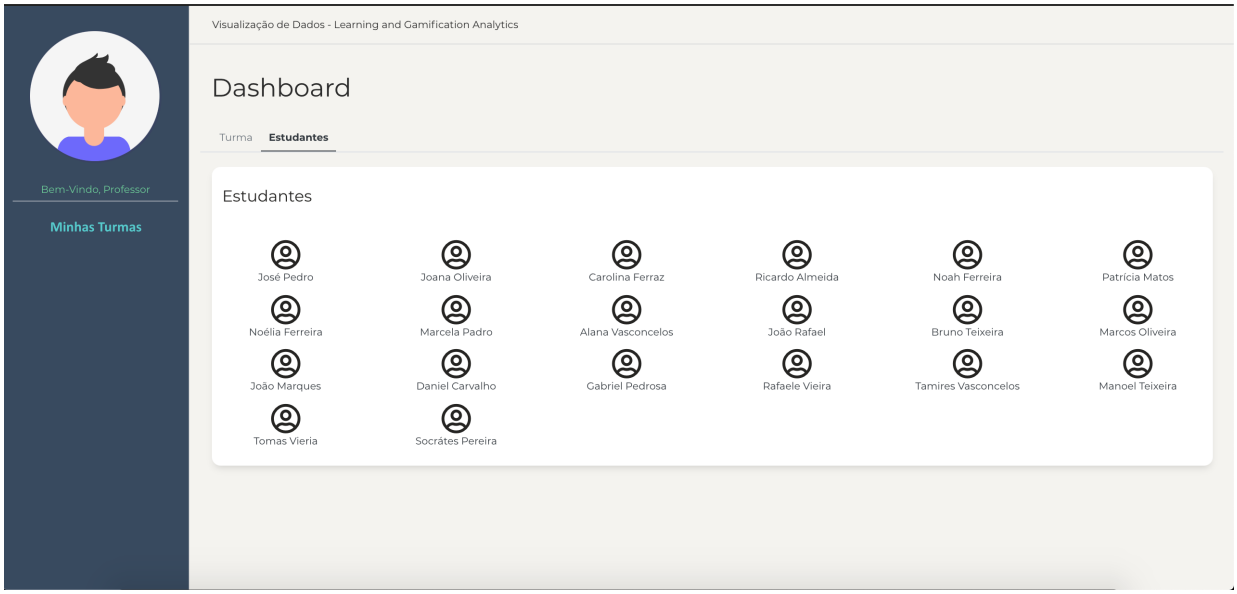
-Visualization of student's progress over time (See Fig. 29): In the student's dashboard, there is a time chart where teachers can visualize the student's progress over time concerning the interaction with learning resources. Moreover, in this time chart is possible to visualize the minimum needed percentage that the student should achieve in order to advance

Figure 26 – **GAMANALYTICS: Class Dashboard - Visualization of the status of each mission created and visualization of each student's interaction with the created missions**



Picture Source: Author

Figure 27 – **GAMANALYTICS: List of students enrolled in the course**

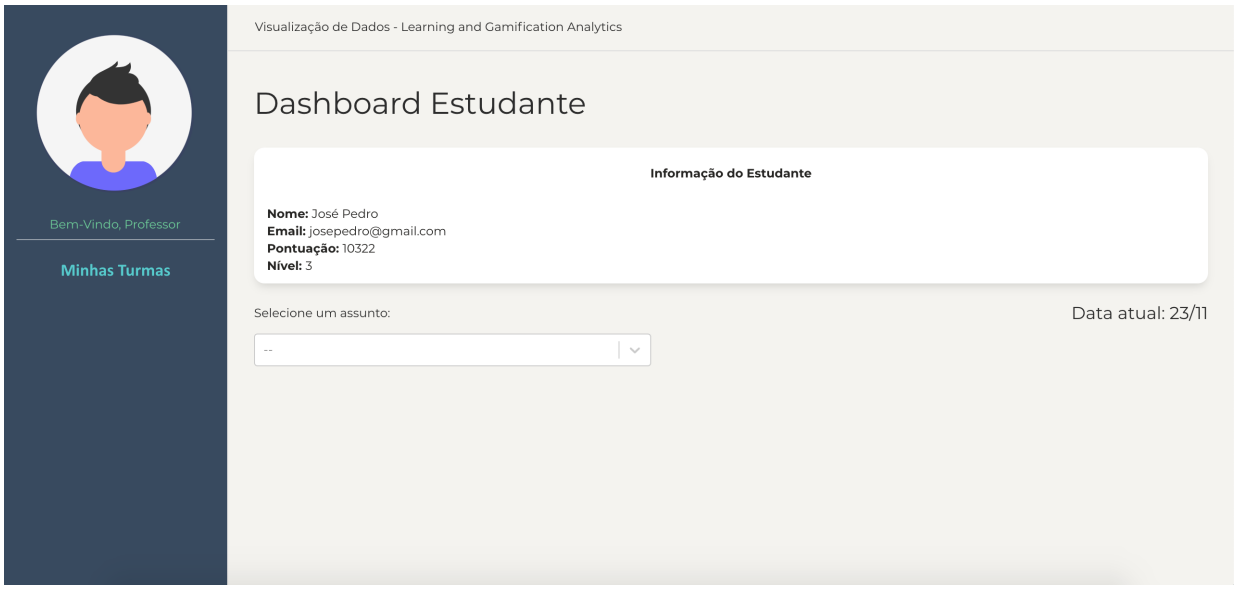


Picture Source: Author

to the next topic. This indication serves as metrics for teachers, comparing the percentage progress of the student with what is expected in relation to the interaction goal of the referred topic. The period expected for the student to master the chosen topic is also showed in this time graph for also serve as a metric for teachers.

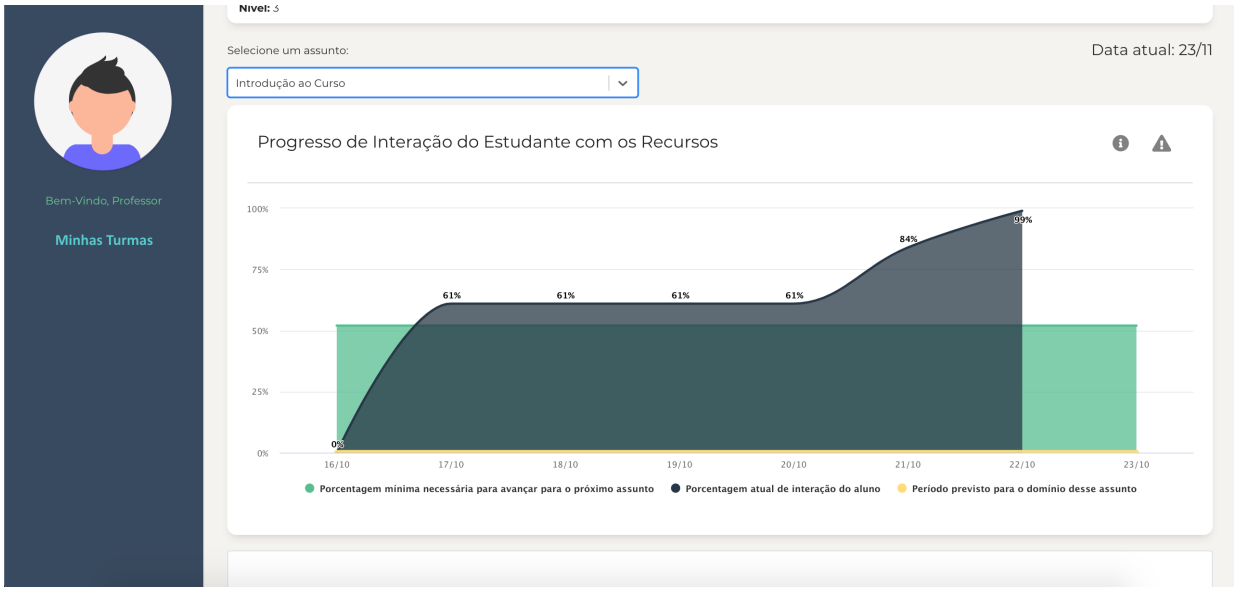
-Visualization of the interaction of the student with learning resources (See Fig. 30): In the student's dashboard, the teacher can visualize the interaction of the student with each learning resource (such as pdf, problems, links, assessments, exercises) of the chosen

Figure 28 – **GAMANALYTICS: Student's Dashboard - Visualization of the student's descriptive data**



Picture Source: Author

Figure 29 – **GAMANALYTICS: Student's Dashboard - Visualization of the student's progress over time**



Picture Source: Author

topi and understand the current status of the student.

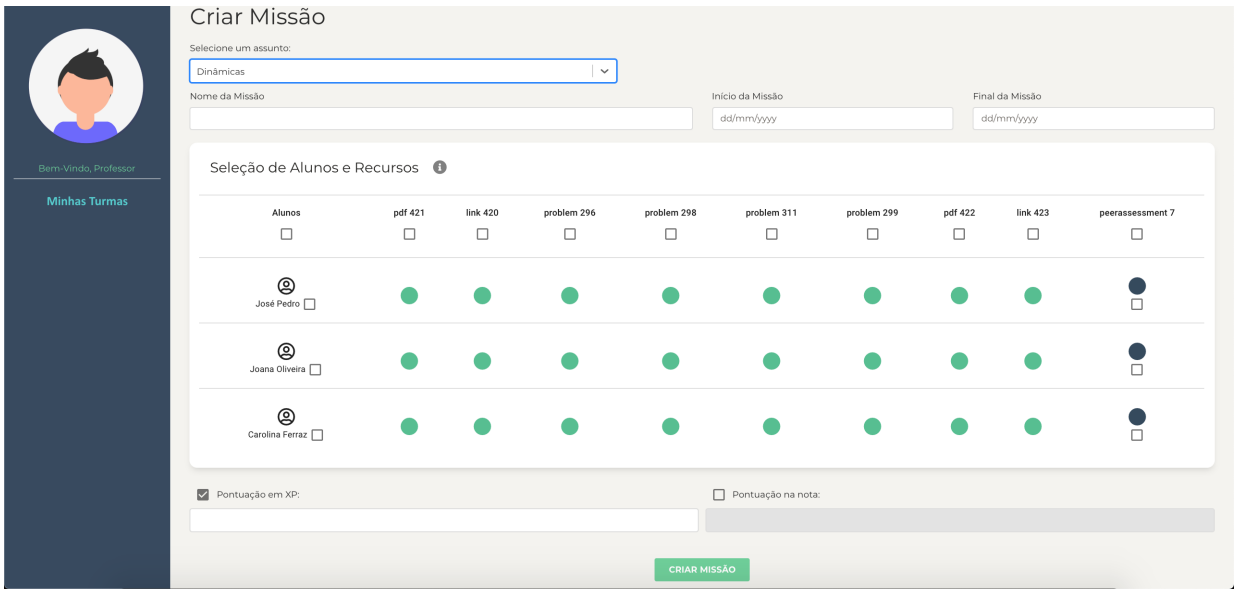
-**Creation of personalized missions for a student or for a specific group by teachers (See Fig. 31):** In order to motivate students to engage with the learning resources when the interactions' goals are not being achieved, teachers can create missions for specific students. At this stage, teachers define the name of the mission being created and the period in which the mission will be available in the gamified learning system. In addition, teachers can select which resources will comprise the mission, as well as the students who will be

Figure 30 – **GAMANALYTICS: Student's Dashboard - Visualization of the interaction of the student with learning resources**

Picture Source: Author

targeted by the mission. Finally, teachers can choose the mission reward for students who are successful. These rewards can be XP points (concept related to gamification) or an increase in the percentage of students' grades.

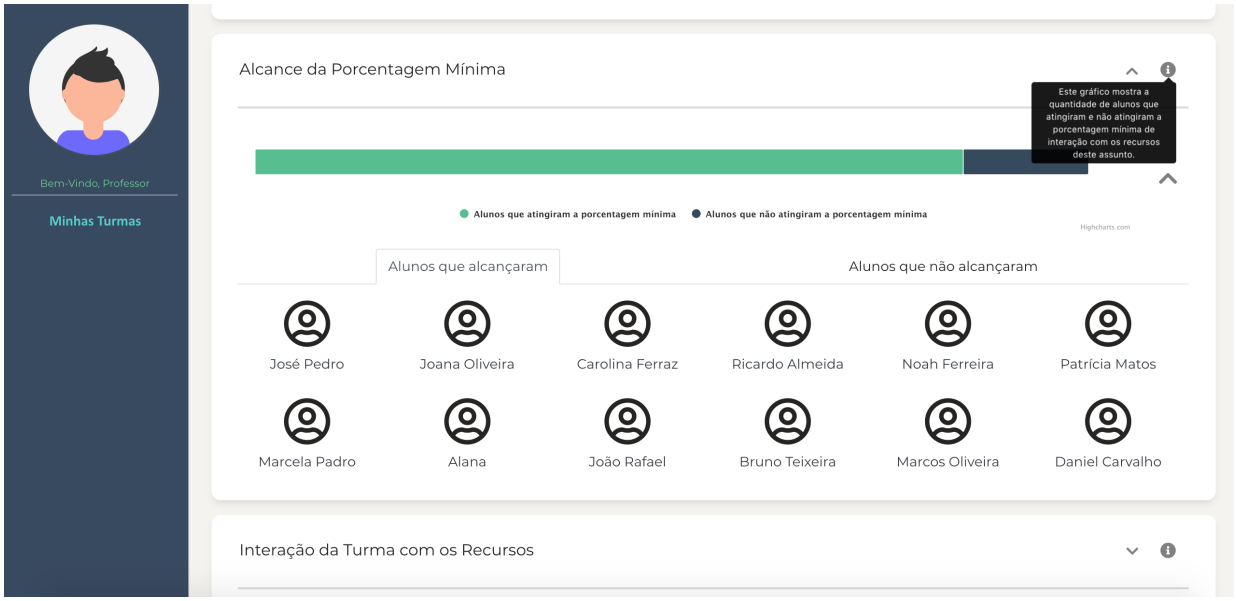
Figure 31 – **GAMANALYTICS: Creation of personalized missions for a student or for a specific group by teachers**



Picture Source: Author

-**Help button provided for each visualization describing its functionality:** Each chart provided in the dashboards contains a help button describing its functionality (an example can be seen in Figure 32). This artifact helps teachers understand the relevance of the chart and how it can be used in the decision process.

Figure 32 – **GAMANALYTICS: Help Button describing the functionality of each chart provided in the dashboards**



Picture Source: Author

7 EVALUATION OF THE GAMANALYTICS TOOL WITH TEACHERS

Considering that one of the objectives of this dissertation is to develop a tool based on the gamification analytics model for teachers to be used in an intuitive, meaningful, enjoyable and effortless way, an evaluation was conducted with teachers to validate the GamAnalytics. Although the GamAnalytics tool was designed based on the design concepts already validated by teachers, the objective in this step is to analyze teachers' acceptance of the final tool, i.e. with the union of all design concepts in a single tool.

Participants of this research were invited by email. Note that before sending these invitations, a pilot study was conducted in laboratory settings (i.e, in the NEES research group) to receive feedback and to adjust the instrument [1].

In the following sections, the objective, materials and method used in this research, the participants, instruments and procedures, the results, analysis and discussion of the results are described.

7.1 Planning

7.1.1 Research Objective

This research intends to evaluate the GamAnalytics tool regarding perceived usefulness, perceived ease of use, behavioral intention, relevance, perceived enjoyment, and self-efficacy constructs, as well as verify the credibility of the tool and its positive and negative points according to teachers in order to improve future versions.

7.1.2 Materials and methods

In this section, we describe the metrics investigated in this research. In order to achieve the objective of this study, a mixed research method was adopted, considering that experts argue that this research method has the potential to provide a greater depth and breadth of information than utilize a qualitative or quantitative approach in isolation (ALMALKI, 2016).

7.1.2.1 Metrics

As we intend to evaluate if the GamAnalytics tool can be used in a intuitive, meaningful, enjoyable and effortless way by teachers, the GamAnalytics tool was analyzed with respect

[1] <https://gamanalytics.nees.com.br/>

to several constructs based on the Technology Acceptance Model (TAM), the most widely employed model of IT adoption and use (VENKATESH; BALA, 2008). TAM is an effective and powerful model that has been validated in diverse contexts to predict and explain users' behavioral intentions (BI) in using technologies (VENKATESH; BALA, 2008). According to TAM, individuals' behavioral intention to use an IT is determined by two beliefs: perceived usefulness and perceived ease of use. Moreover, job relevance is a determinant of Perceived Usefulness, and perceived enjoyment, self-efficacy and computer anxiety are determinants of perceived ease of use.

These constructs are described on below:

- **Perceived usefulness (PU):** This construct is related to the extent to which a person believes that using the system that is being evaluated will enhance his or her job performance (VENKATESH; BALA, 2008). There were four items in the final questionnaire concerning this construct, and items were measured on a 7-point Likert scale from 1 (strongly disagree) to 7 (strongly agree).

- **Perceived ease of use (PEOU):** This construct is related to how easy or difficult is to use the system that is being evaluated (VENKATESH; BALA, 2008). There were four items in the final questionnaire concerning this construct. Items were measured on a 7-point Likert scale from 1 (strongly disagree) to 7 (strongly agree).

- **Behavioral intention (BI):** This construct is related to the degree of a teacher's willingness to use technology (VENKATESH; BALA, 2008). (strongly agree). There were three items in the final questionnaire concerning this construct, and items were measured on a 7-point Likert scale from 1 (strongly disagree) to 7 (strongly agree).

- **Job Relevance (REL):** This construct is related to the degree which an individual believes the system that is being evaluated is applicable to his or her job (VENKATESH, 2000). There were three items in the final questionnaire concerning this construct. Items were measured on a 7-point Likert scale from 1 (strongly disagree) to 7 (strongly agree).

- **Perceived enjoyment (ENJ):** This construct is related to the extent to which the activity of using the system that is being evaluated is perceived to be enjoyable in its own right, aside from any performance consequences resulting from system use (VENKATESH, 2000). There were three items in the final questionnaire concerning this construct. Items were measured on a 7-point Likert scale from 1 (strongly disagree) to 7 (strongly agree).

- **Self-efficacy (CSE) :** This construct is related to individuals' control beliefs regarding his or her personal ability to use the system that is being evaluated (VENKATESH; BALA, 2008). There were three items in the final questionnaire concerning this construct. Items were measured on a 7-point Likert scale from 1 (strongly disagree) to 7 (strongly agree).

Anxiety (CANX): This construct is related to the degree of an individual's apprehension, or even fear, when she/he is faced with the possibility of using the system that is being

Table 6 – Questions used in the Final Questionnaire

Final Questionnaire
Perceived usefulness (PU):
PU1: Using the tool improves my performance in dealing with my students' engagement problems.
PU2: Using the tool increases my productivity.
PU3: The use of the tool increases my effectiveness in the process of dealing with my students' engagement problems.
PU4: I find that the tool is useful in the process of dealing with my students' engagement problems.
Perceived ease of use (PEOU):
PEOU1: The use of the tool was clear and understandable.
PEOU2: The interaction with the tool does not require much of my mental effort.
PEOU3: I find that the tool is easy to use.
PEOU4: I find it easy to interact with the tool to do what I want.
Behavioral intention (BI):
BI1: Assuming I have access to the tool, I intend to use it.
BI2: Since I have access to the tool, I predict that I will use it.
BI3: I plan to use the tool in the coming months.
Job Relevance (REL):
REL1: In the process of dealing with my students' engagement problems, the use of the tool is important.
REL2: In the process of dealing with my students' engagement problems, the use of the tool is relevant.
REL3: The use of the tool is relevant for several situations.
Perceived enjoyment (ENJ):
ENJ1: I find that using the tool is pleasant.
ENJ2: The current process of using the tool is pleasant.
ENJ3: I had fun using the tool.
Self-efficacy (CSE):
CSE1: I cannot complete the use of the tool if there is no one around to tell me what to do.
CSE2: I cannot complete using the tool unless someone shows me how to do it first.
CSE3: I could not complete using the tool if I had not used similar tools before this activity.
Computer anxiety (CANX):
CANX1: Using the tool doesn't scare me at all.
CANX2: Working with the tool makes me nervous.
CANX3: Using the tool makes me feel uncomfortable.
Credibility (CR): What is the credibility of the presented tool?
Open Question 1: Describe the negative points about this version of the tool.
Open Question 2: Describe the positive points about this version of the tool.

evaluated. There were three items in the final questionnaire concerning this construct. Items were measured on a 7-point Likert scale from 1 (strongly disagree) to 7 (strongly agree).

Moreover, the credibility of the tool was also evaluated:

Credibility (CR): This variable captures the overall credibility of a prototype based on users' perceptions. The credibility is measured in a scale from 1 to 10 (DERMEVAL, 2017).

Considering that a mixed research method was adopted, two open-ended questions were included in the final questionnaire in order to evaluate teachers' positive and negative points of view concerning the tool.

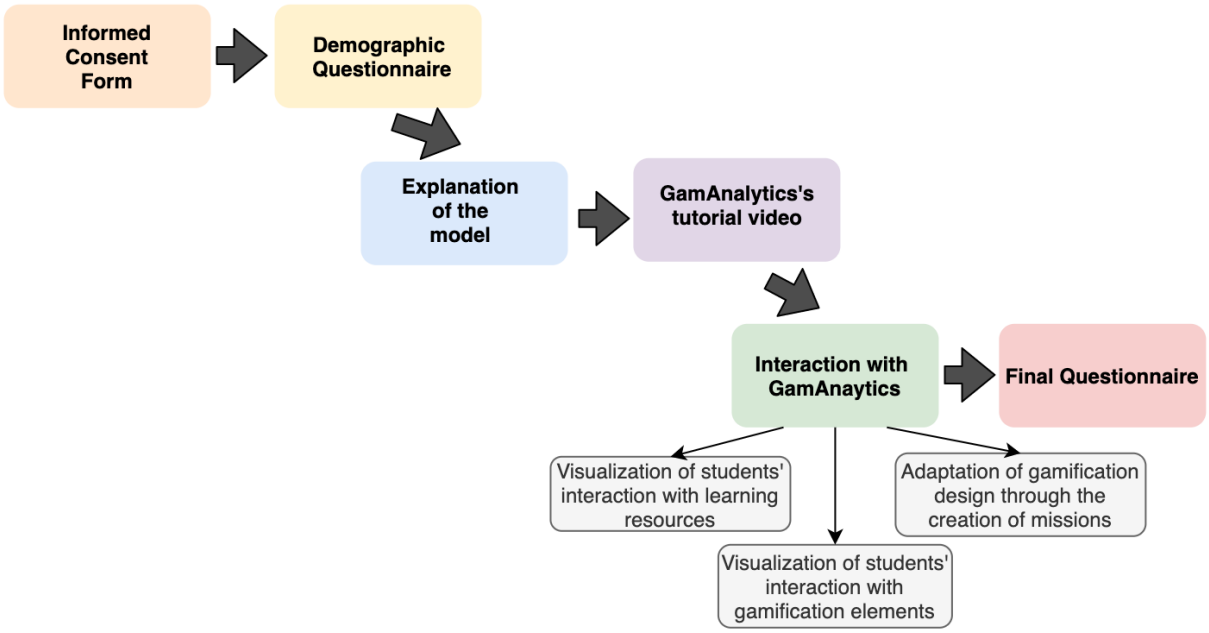
7.1.3 Participants

In order to achieve this objective, it was conducted a research with 57 teachers (invited by email) with different backgrounds and working at different educational levels.

7.1.4 Instruments and Procedure

Through the following instrument <https://gamanalytics.nees.com.br/>, teachers read about the research objective and were asked to give their informed consent. Then, teachers answered their demographic information (age, gender, educational level and study domain that they teach). Teachers also read about the Gamification Analytics model (Section 4) that was the basis for the development of the GamAnalytics tool and watched the video tutorial that explains how the tool works. After that, teachers were asked to interact with the prototype of the tool. In this step, teachers monitored students' interaction with the learning resources, monitored students' interaction with the gamification elements and created a mission. Finally, teachers answered the final questionnaire evaluating the tool they interacted with. The final version of the questionnaire comprised 26 questions including 2 open questions (see Table 6). The research procedure can be seen in Fig. 34.

Figure 33 – **Validation' Process Design**



Picture Source: Author

7.2 Results

This section presents the analysis of the data collected in this research. Before presenting the statistic results, it was depicted the demographic statistics of the participants of this study.

As previously explained, teachers provided information about their age, gender, educational level and study domain that they teach. In Table 7, it is possible to visualize the participants' demographics information. In this dissertation, it was adopted the educational stage classification used by the USA: pre-kindergarten, kindergarten, elementary school, secondary school, post-secondary, post baccalaureate and post-doctorate level (CORSI-BUNKER, 2000). Note that some teachers pointed out that they teach at more than one educational level.

7.2.1 Quantitative Results

Before conducting statistical analysis, reliability assessment was done using Cronbach Alpha. In this study, the internal consistency of all subscales in the final questionnaire was greater than .70, seen in Table 8. Therefore, the survey data might be considered reliable and valid.

7.2.1.1 Perceived usefulness

As seen in Table 9, the majority of the items' mean of the construct Perceived Usefulness were superior to 5, and the mean overall of this construct was 5.192, indicating that the participants' evaluation was positive (See Table 10). Moreover, according to Table 11, most teachers participants (37 out of 57 teachers/64,91%) highly agreed that GamAnalytics is a useful tool. It is also important to note that no teacher evaluated the tool with a low rating in relation to its usefulness.

7.2.1.2 Perceived Ease of use

Concerning the Perceived Ease of use, all items' mean were superior to 5 (See Table 9), and the mean overall of this construct was 5.482 (See Table 10), a high rating. Furthermore, the majority of teachers (46 out of 57 teachers/80.70%) highly agreed that GamAnalytics is a tool of ease use, as seen in Table 11. Only 3 teachers gave low ratings regarding the ease of use of the tool. One possible reason for it is due to these teachers are from the social studies area and do not make frequent use of technology in the educational field. Therefore, although the GamAnalytics be an intuitive tool, there are some barriers for teachers that are not used to these technologies.

7.2.1.3 Behavioral intention

The majority of the items' mean of the construct Behavioral intention were superior to 5, as seen in Table 9, and the mean overall of this construct was 5.093, which means a satisfactory outcome (See Table 10). Moreover, according to Table 11, most teachers participants (36 out of 57 teachers/63,15%) are willing to use the GamAnalytics tool.

Table 7 – Participants' demographics information

Age	**Number of Participants**	**Percentage (%)**
18 - 25	1	1,75%
26 - 40	24	42,10%
41 - 65	30	52,63%
Over 65	2	3,50%
Rather not say	0	-
Gender	**Number of Participants**	**Percentage (%)**
Female	25	43,85%
Male	32	56,15%
Rather not say	0	-
Educational level that teaches	**Number of Participants**	**Percentage (%)**
Pre-kindergarten	0	-
Elementary school	3	5,26%
Secondary school	5	8,77%
Post-secondary	53	92,98%
Post baccalaureate	14	24,56%
Post-doctorate level	0	-
Study domain that teaches	**Number of Participants**	**Percentage (%)**
Science/Biology	11	19,29%
Social Studies	10	17,54%
IT	6	9,43%
Languages	5	8,77%
Engineering	5	8,77%
Mathematics	4	7,01%
Pedagogy	4	7,01%
Architecture and Design	4	7,01%
Chemistry	3	5,26%
Entrepreneurship	3	5,26%
Psychology	2	3,50%

7.2.1.4 Relevance

The mean of all items of the Relevance construct was superior to 5, a high rating, according to Table 9. It is important to note that the relevance construct was the best-evaluated construct by the teachers, the mean overall was 5.502 (See Table 10). Therefore, it is an indication that teachers believe that the tool is applicable to his or her job. Moreover, the majority of teachers (48 out of 57 teachers/84.21%) highly agreed that GamAnalytics is relevant for them, as seen in Table 11.

7.2.1.5 Perceived enjoyment

The perceived enjoyment in using the GamAnalytics tool by the teachers was also well evaluated. The majority of the items‘ mean of the construct perceived enjoyment were superior to 5, as seen in Table 9, and the mean overall of this construct was 5.187, which means a highly satisfactory result (See Table 10). Furthermore, the majority of teachers (36 out of 57 teachers/63.15%) highly agreed that GamAnalytics is an enjoyable tool to use, as seen in Table 11.

7.2.1.6 Self-efficacy

As seen in Table 9, the average of most items in the Self-efficacy construct was greater than 4 and less than 5, and the overall average of this construct was 4,842, indicating that the participants' assessment was positive, but not high (see table 10). In addition, according to Table 11, almost the majority of teachers' beliefs about their personal ability to use the GamAnalytics tool was also high (28 out of 57 teachers / 49.12%).

7.2.1.7 Computer Anxiety

Teachers‘ apprehension or even fear when they were interacting with the GamAnalytics tool was low. According to Table 9, the mean of all items of the Computer Anxiety construct was inferior to 3, and the mean overall was 2.120 (See Table 10). Furthermore, the majority of teachers (46 out of 57 teachers/80.70%) highly agreed that GamAnalytics does not cause anxiety, as seen in Table 11.

7.2.1.8 Credibility

Between 1 and 10, the tool's average credibility was 8.105 (See Table 10). Therefore, teachers' perception of the credibility of the GamAnalytics tool is highly satisfactory.

Table 8 – Cronbach Alpha Reliability Assessment

Construct	Number of Items	Cronbach Alpha
Perceived usefulness (PU)	4	0.837
Perceived ease of use (PEOU)	4	0.881
Behavioral intention (BI)	3	0,889
Relevance (REL)	3	0.842
Perceived enjoyment (ENJ)	3	0.886
Self-efficacy (CSE)	3	0.763
Computer Anxiety (CANX)	3	0.738
Overall reliability	23	0.841

Table 9 – Mean and Standard Deviation of the items of each construct evaluated

Item	Mean	SD	Item	Mean	SD
Perceived usefulness (PU)			**Perceived ease of use (PEOU)**		
PU1	5.368	1.011	PEOU1	5.701	1.295
PU2	4.771	1.337	PEOU2	5.263	1.330
PU3	5.263	1.061	PEOU3	5.614	1.236
PU4	5.368	1.011	PEOU4	5.350	1.110
Behavioral intention (BI)			**Job Relevance (REL)**		
BI1	5.491	1.416	REL1	5.491	1.136
BI2	5.228	1.402	REL2	5.456	1.036
BI3	4.561	1.337	REL3	5.561	1.086
Perceived enjoyment (ENJ)			**Self-efficacy (CSE)**		
ENJ1	5.526	1.054	CSE1	5.210	1.346
ENJ2	5.350	1.110	CSE2	4.894	1.739
ENJ3	4.684	1.284	CSE3	4.421	1.822
Computer anxiety (CANX)			**Credibility (CR)**		
CANX1	2.017	1.061	CR	8.105	1.377
CANX2	2.192	1.445			
CANX3	2.175	1.364			

Table 10 – Summary of statistics for the eight metrics evaluated in the final questionnaire

	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
Range	0.596	0.438	0.929	0.105	0.842	0.789	0.175	6.0
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

Table 11 – Constructs' Range

Constructs	Average	Scores	Total N=57	Percentage
Perceived usefulness (PU)	High Rating	5.00—7.00	N=37	64.91%
	Medium Rating	3.00—4.99	N=20	35.08%
	Low Rating	<3.00	N=0	–
Perceived ease of use (PEOU)	High Rating	5.00—7.00	N=46	80.70%
	Medium Rating	3.00—4.99	N=8	14.03%
	Low Rating	<3.00	N=3	5.26%
Behavioral intention (BI)	High Rating	5.00—7.00	N=36	63.15%
	Medium Rating	3.00—4.99	N=17	29.82%
	Low Rating	<3.00	N=4	7.01%
Job Relevance (REL)	High Rating	5.00—7.00	N=48	84.21%
	Medium Rating	3.00—4.99	N=7	12.28%
	Low Rating	<3.00	N=2	3.50%
Perceived enjoyment (ENJ)	High Rating	5.00—7.00	N=36	63.15%
	Medium Rating	3.00—4.99	N=20	35.08%
	Low Rating	<3.00	N=1	1.75%
Self-efficacy (CSE)	High Rating	5.00—7.00	N=28	49.12%
	Medium Rating	3.00—4.99	N=24	42.10%
	Low Rating	<3.00	N=5	8.77%
Computer anxiety (CANX)	High Rating	5.00—7.00	N=1	1.75%
	Medium Rating	3.00—4.99	N=10	17.54%
	Low Rating	<3.00	N=46	80.70%

7.2.2 Qualitative Results

As mentioned earlier, the final questionnaire contained two open-ended questions. In the first open-ended question, teachers were asked to point out the positive points of the tool while in the second open-ended question, the teachers were asked to point out the negative points of the tool. These two questions were the only optional ones in the final questionnaire.

Of the 57 survey participants, 17 teachers pointed out the tool's positive points and 4 teachers pointed out negative points. The data collected was examined using an open coding scheme, the analytic process through which concepts are identified in data (CORBIN; STRAUSS, 2008). Teachers' answers were grouped into categories to get a better understanding of their opinions.

The answers gathered in the first question were classified into three major categories: usefulness, ease of use, relevance.

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. "It allows the teacher to detect the evolution of the class's learning more easily".

3. "When you become familiar with the tool, the method is certainly very useful".

4. "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. "Easy to use, understandable design, meets a demand."

4. "The tool's appearance seemed more dynamic than the AVA Moodle used in universities."

5. "I liked the fluidity of the navigation in the system; The system is very straightforward, with no factors to confuse."

6. "The tool expresses a plausible teaching dynamic. I liked the way mission ideas were conceived."

7. "It is easy to use and very practical."

8. "The tool is easy to use and allows you to easily and directly follow the evolution of each student in the discipline."

9. "The graphics and "friendly" way in which the tool was presented make it easy to

use and self-instructive."

10. "Good interactivity and easy to understand steps related to the process."

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."

3. "Highly relevant objective which is to assist students with different assimilation rates."

The answers gathered in the second question were classified into two major categories: usefulness, ease of use.

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 in order 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 interactive way, easy for those users who do not have affinities with the computational environment. Not all teachers have mastered or are able to master/understand the computational resources for the adequate/effective use of this tool. "

7.3 Discussion

Considering that one of the objectives of this dissertation is to develop a tool based on the gamification analytics model for teachers that can be used in an intuitive, meaningful, enjoyable and effortless way, teachers' perception 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 constructs. According to the quantitative results, most teachers participants' perceptions concerning the GamAnalytics tool are positive, mainly concerning the perceived ease of use and relevance of the proposed tool.

In relation to the qualitative results, most results were positive concerning the tool.

Teachers mainly pointed out that the tool is useful, easy of use and relevant for their jobs. Participants teachers mainly pointed out the ease of use of the tool, of the 17 responses that pointed out positive points, 10 of them were about ease of use. This result shows that the tool may have achieved the goal of being intuitive and do not require high effort from teachers to use it. Moreover, four teachers 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.

Moreover, the number of responses from teachers pointed out negative points was quite low (4 teachers' answers) compared to the number of answers pointed out positive points (17 teachers' answers). This is one more indication that the teachers evaluated the tool more positively than negatively. Two teachers expressed their opinion concerning the usefulness of the tool. The first teacher pointed out that the tool cannot detect daily problems that students may face and this could have a negative impact on students' learning performance. The second professor pointed out that the tool can obtain better results including artificial intelligence for the creation of missions. Finally, two teachers talked about 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, game logic.

Therefore, these negative opinions will be valued to improve future versions of the GamAnalytics tool. As pointed out by a professor, the tool could be complemented by applying artificial intelligence techniques to generate automated missions to students. Artificial intelligence can also be used to help teachers identify the best times to assign missions and to identify students most at risk of not meeting interaction goals, helping them in the making-decision process. Furthermore, nine teachers indicated that they could not point out 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.

However, this study presents some validity threats. First, the empirical strategy, survey, was chosen in this study because it could provide a broad overview (WOHLIN et al., 2012), thus there were many questions to evaluate different constructs. Therefore, 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 generate the reported results. However, to minimize it, in the study was considered teachers of different educational levels, who teach different fields of study, and from different regions of the country (Brazil).

8 CASE STUDY

The main goal of the use of the gamification analytics model by teachers is to impact positively on students' engagement, learning outcomes, and motivation during the learning process in gamified learning systems. Therefore, in this chapter, we present the method and results of a case study that was conducted in a real scenario to investigate the impact of the model on students' outcomes.

8.1 Case Study Planning

8.1.1 Objective

The main objective of the case study was to explore the impact of teachers' use of the gamification analytics model through the GamAnalytics tool on students' learning, engagement and motivation in a "Gamification in Education" course. The case study was conducted to address the following hypotheses:

H1: Students will engage with the "Gamification in Education" course's resources.

H2: Students will gain knowledge of the "Gamification in Education" topics.

H3: Students will be motivated to interact with the "Gamification in Education" course's resources.

8.1.2 Materials

Two systems were used in this research in a complementary way, i.e the GamAnalytics tool was connected to a gamified educational environment, the Avance[1]. Avance is composed by two modules (explained in Section 2). The first module provides an environment for teachers that enables them to plan the classes, to decide which resources students will interact to master the topic of the disciplines and to define the expected interaction objectives of the students in each topic. The second module (in the Avance platform) supports students in the coutse's learning process. In this module, students can access the course's teacher planning and interact with the resources of each topic of the course. As Avance is a gamified educational environment, so according to the interaction of students with the resources added by the teacher, they earn points, trophies and position in the ranking.

The GamAnalytics tool (explained in Section 2) was connected to the database of the Avance platform. Therefore, teachers linked to the Avance gamified educational environment can access the GamAnalytics tool to intuitively view students‘ interaction data with the Avance

[1] <avance.eyeduc.com>

platform's learning and gamification resources, to monitor and understand the status of the class and its students in relation to their level of interaction with the learning and gamification resources, and consequently intervene in the scenario, if they judge necessary.

8.1.3 Participants

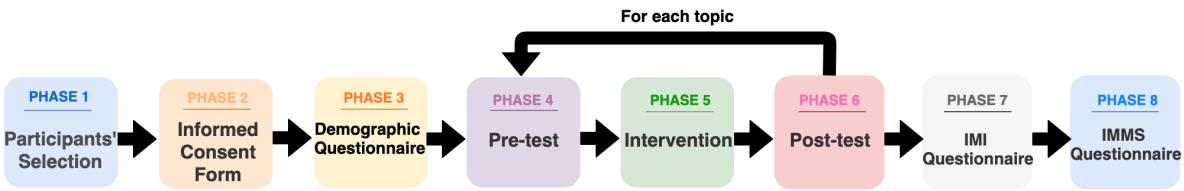
The case study was conducted in January 2020 with students of the Federal University of Alagoas who were enrolled in the *"Gamification in Education"* course. The sample consisted of 10 students (aged between 18 and 30 years old; 6 were male participants and 4 were female participants) where 7 were undergraduate students in Computer Engineering, 1 was an undergraduate student in Design, 1 was a master student in Informatics, and 1 was a master student in Education.

8.1.4 Instruments and Procedure

Considering that the objective of the case study is to evaluate the impact of the use of the gamification analytics model through the GamAnalytics tool by teachers on students' learning, engagement and motivation on two topics of the "Gamification in Education" course, some questionnaires were designed by the researchers: a demographic questionnaire to understand students' profile; a pre-test and post-test questionnaires of each topic learned to measure students' knowledge of "Gamification in Education" before and after the intervention, IMI (*Instructional Materials Motivation Survey*) and IMMS (*Instructional Materials Motivation Survey*) questionnaires to measure students' motivation during the intervention.

The case study' process can be seen in Fig. 34. The case study lasted for four weeks, which was the expected time for students to master the subject "Framework, models and processes" (expected time: 1 week) and the subject "Gamiflow" (expected time: 2 weeks) and consisted of the following phases:

Figure 34 – **Case Study' Process**



Picture Source: Author

Phase 1 (Selection of participants): In this phase, a teacher from the "Gamification in Education" course and their respective students were selected.

Phase 2 (Preparation): In the second phase, the informed consent form was first signed by the students. Afterward, the teacher received an explanation of the purpose of the

case study and how it would be conducted. After the explanation, the teacher made some changes in the course planning using the Educational platform Avance. In this stage, the interaction goals that teachers expected students to achieve for the domain of each topic were defined (e.g: interacting with 60 % of the available resources of the topic "Gamiflow" in 2 weeks).

Phase 3 (Informed Consent Form and Demographic Questionnaire): In the third phase, after the teacher prepared the educational platform, students received a Weblink explaining the purpose of the case study and how it would be conducted. Also through this Weblink, students read and accepted the informed consent form [2] (Appendix J) and completed a demographic questionnaire.

Phase 4 (Pre-test): In this phase, students answered a pre-test on each of the two subjects that were taught during the case study period through a Weblink. The pre-tests (Appendices C and E) were reviewed by the professor of the course, with questions related to the topics they would study. Pre-tests were planned according to the levels of the revised Bloom taxonomy (KRATHWOHL, 2002) to be balanced with the post-tests.

Phase 5 (Intervention): In this phase, students began to interact with the topic resources on the gamifed adaptive educational environment. While students interacted with the platform, teachers could visualize students' data related to their interactions with the learning resources and the gamification elements through the GamAnalytics tool. When teachers realized that gamification design was not promoting effective students' engagement and/or students' interaction with resources were not as expected, they were able to adapt the gamification design by assigning missions to groups or to a specific student who did not was getting the expected results. The missions were sent by e-mail by the teacher to students. In the email, a set of resources is recommended by the teacher expecting that students interact with them in the gamifed adaptive educational environment. The expected period and the reward that students would receive after completing the mission were presented in the email. After that, they were able to visualize the impact of this intervention through the GamAnalytics tool. This process was repeated until the planned time to complete the case study finish. For each topic, teachers created 3 different missions depending on the level of students' interaction. Mission 1 was addressed to the students that did not interact with the learning resources. Mission 2 was addressed to students that interacted with some resources, bud did not achieve the interaction goals. Finally, mission 3 was addressed to the students that achieved the interaction goals, aiming to improve even more their understanding of the topic. Each student received one mission related to each of the two topics.

Phase 6 (Post-test): In this phase, students answered the post-tests (Appendices D and F) concerning the topics learned through a Weblink to assess whether they have mastered the topics properly. The post-tests were planned based on the revised Bloom taxonomy

[2] Approved in the ethical committee of the Federal University of Alagoas (CAAE: 26305419.4.0000.5013)

(KRATHWOHL, 2002) to be balanced with the pre-tests.

Phase 7 (IMI questionnaire): After the post-test of the last topic, students answered the IMI questionnaire (*Intrinsic Motivation Inventory*) (Appendix G) (GROLNICK; RYAN, 1987) (RYAN; CONNELL, 1989) (RYAN; MIMS; KOESTNER, 1983) through a Weblink to measure the intrinsic motivation in relation to the topics, based on the self-determination theory. The factors that were used to measure intrinsic motivation were: *interest/enjoyment*, *perceived choice* and *pressure/tension*. The questionnaire was validated in the Portuguese-Brazilian language (CHALLCO, 2019).

Phase 8 (IMMS questionnaire): The IMMS questionnaire (*Instructional Materials Motivation Survey*) (Appendix H), a model designed by Keller (KELLER, 1987) (SONG; KELLER, 2001), was also applied to measure participants' motivation based on the ARCS model (attention, relevance, and satisfaction). This questionnaire was validated in the Portuguese-Brazilian language (CHALLCO, 2019). The factors that were used to measure motivation were: attention, relevance and satisfaction.

After completing the case study, some essential data were collected directly from the Avance educational platform (daily interaction with learning resources) and others were extracted through pre-tests and post-tests, questionnaires. Finally, the analysis of the collected data was carried out.

8.2 Case Study Results

8.2.1 Effects on Learning

The analysis of the impact on the use of the gamification analytics model by teachers through the GamAnalytics tool on students' learning was performed through a pre-test and a post-test taken by students before and after the domain of each topic learned during the case study.

8.2.1.1 "Frameworks, Models and Process" Topic:

A Shapiro-Wilk test was performed to evaluate the distribution of the pre-test and post-test scores achieved by students. The outcome obtained after execution of the test of normality indicates that the data may come from a normally distributed population (pre-test: W = 0.965, p-value = 0.843 / post-test: W = 0.932, p = 0.473).

As data come from a normal distribution, a t-test was performed. The results indicate that there is a statistically significant difference between the scores (pre-test scores: M = 5.10, SD = 2.183 / post-test scores: M = 7.40, SD = 2.119, t(9) = -4.116, p-value = 0,003).

Therefore, our results might suggest that students have improved their understanding

of the “Frameworks, Models and Processes” topic of the "Gamification in Education" course after interacting with the resources sent by teachers through missions.

8.2.1.2 “Gamiflow" Topic:

A Shapiro-Wilk test was also performed to evaluate the distribution of the pre-test and post-test scores of “Gamiflow" topic achieved by students.

The outcome obtained after execution of the test of normality indicates that the data may come from a normal distribution (pre-test: W = 0.909, p-value = 0.271 / post-test: W = 0.916, p-value = 0.325). As such, a t-test was performed. The results indicate that there is a statistically significant difference between the scores (pre-test scores: M = 5.30, SD = 2.003 / post-test scores: M = 6.90, SD = 1.663, t(9) = -2.449, p-value = 0,037).

Thus, these results may also suggest that students have improved their understanding of the “Gamiflow” topic of the "Gamification in Education" course after interacting with the resources sent by teachers through missions.

8.2.2 Effects on Engagement

8.2.2.1 “Frameworks, Models and Process" Topic:

To test hypothesis H1, aiming to investigate if students are engaged to interact with “Frameworks, Models and Process" topic resources, the quantity of students' interaction with the topic's resources before and after teacher's intervention through the creation of missions were measured.

A Shapiro-Wilk test of normality distribution was performed to examine the distribution of the number of interactions with topic's resources made by the students before and after the teacher's intervention based on the monitoring of students' information. The test results indicate that the data are not from a normal population (W = 0.594, p-value = 0.000; W = 0.618, p-value = 0.000, respectively).

Thus, a non-parametric Wilcoxon signed-rank test was performed to compare the number of students' interaction before and after the teacher's adaptation of gamification design. The Wilcoxon signed-rank test indicated that there is a statistically significant difference between the number of interactions before (M = 5.40) and after the teacher's intervention (M = 12.70), Z = -2.121, p-value = 0.034.

Therefore, students increased significantly their interaction with "Gamification in Education" course's resources after the teacher's intervention based on the monitoring of students' information, suggesting that students have improved their interaction with the system after teachers intervention.

8.2.2.2 "Gamiflow" Topic:

We also run a Shapiro-Wilk test to examine the distribution of the number of students' interactions with "Gamiflow" topic's resources before and after the teacher's intervention. The test results indicate that the data are not from a normal distribution (W = 0.812, p-value = 0.020; W = 0.432, p-value = 0.000, respectively).

A Wilcoxon signed-rank test was performed to compare the number of students' interactions before and after the teacher's assignment of missions. The test's outcome indicate that there is a statistically significant difference between the number of interactions before (M = 29.70) and after the teacher's intervention (M = 56.70), Z = -2.214, p-value = 0.027, also suggesting that students have increased their engagement after interacting with missions sent by teachers.

8.2.3 Effects on Motivation

In order to assess whether the proposed model had a positive impact on students' motivation, the IMI and IMMS questionnaires were answered by the participants after the period foreseen for the domain of each topic was finalized. The IMI and IMMS questionnaires for motivation use a 7-point Likert scale.

"Frameworks, Models and Process" Topic:

IMI Questionnaire: The internal consistency (Cronbach's alpha) for the Interest/Enjoyment (6 items), Perceived Choice (3 items), Pressure/Tension (3 items) subscales was greater than .70. As seen in Table 12, among the 10 students who participated in the case study, the minimum overall intrisic motivation was 4.0 and the maximum overall intrisic motivation was 5.33.

Moreover, the mean overall intrinsic motivation score during the teaching of "Frameworks, Models and Process" topic was 4.52, which means a satisfactory outcome. According to Table 13, most of the students (90%) presented a medium level of intrinsic motivation, and 10% presented a high level of motivation. Our results may suggest that students were more intrinsically than extrinsically motivated during the intervention in the "Frameworks, Models and Process" topic.

IMMS Questionnaire: The internal consistency (Cronbach's alpha) for the Attention (6 items), Relevance (3 items), and Satisfaction (3 items) subscales was greater than .70. With respect to students' motivation level during the teaching of "Frameworks, Models and Process" topic, as seen in Table 14, the minimum overall motivation level was 4.0 and the maximum overall motivation level was 7.0.

Furthermore, the mean overall motivation level score during the teaching was 5.19, which means a satisfactory outcome. According to Table 15, half of the students (50%) presented a high intrinsic motivation level, and the other half 50 % presented a medium

Table 12 – Scores of Intrisic Motivation

Topic	Scale	Minimum	Maximum	Mean	SD
Frameworks, Models and Process	Interest/Enjoyment	4.0	6.0	4.73	0.61
	Perceived Choice	4.0	6.66	4.93	1.01
	Pressure/Tension	1.0	5.0	2.43	1.35
	Overall	4.0	5.33	4.52	0.37
Gamiflow	Interest/Enjoyment	1.66	7.0	4.63	1.48
	Perceived Choice	1.60	6.80	4.14	1.28
	Pressure/Tension	1.0	4.0	2.30	1.19
	Overall	2.07	5.30	4.63	1.04

Table 13 – Range of Intrisic Motivation

Topic	Intrisic Motivation	Scores	Total N=10	Percentage
Frameworks, Models and Process	High Intrisic Motivation	5.00—7.00	N=1	10%
	Medium Intrisic Motivation	3.00—4.99	N=9	90%
	Low Intrisic Motivation	<3.00	N=0	–
Gamiflow	High Intrisic Motivation	5.00—7.00	N=6	60%
	Medium Intrisic Motivation	3.00—4.99	N=3	30%
	Low Intrisic Motivation	<3.00	N=1	10%

Table 14 – Scores of Motivation Level

Topic	Scale	Minimum	Maximum	Mean	SD
Frameworks, Models and Process	Attention	3.66	7.0	4.95	1.04
	Relevance	3.66	7.0	5.40	1.14
	Significance	4.0	7.0	5.46	0.89
	Overall	4.0	7.0	5.19	0.88
Gamiflow	Attention	3.0	7.0	5.0	1.37
	Relevance	2.50	7.0	4.81	1.29
	Significance	2.0	7.0	5.06	1.45
	Overall	2.61	6.76	4.95	1.31

motivation level. In conclusion, we might suggest that the students were motivated during the intervention in the “Frameworks, Models and Process" topic.

“Gamiflow" Topic:

IMI Questionnaire: The internal consistency (Cronbach's alpha) for the Interest/Enjoyment (6 items), Perceived Choice (5 items), Pressure/Tension (3 items) subscales was greater than .70. As seen in Table 12, among the 10 students who participated in the case study, the

Table 15 – Range of Motivation Level

Topic	Motivation Level	Scores	Total N=10	Percentage
Frameworks, Models and Process	High Level	5.00—7.00	N=5	50%
	Medium Level	3.00—4.99	N=5	50%
	Low level	<3.00	N=0	–
Gamiflow	High Level	5.00—7.00	N=5	50%
	Medium Level	3.00—4.99	N=4	40%
	Low level	<3.00	N=1	10%

minimum overall intrisic motivation of the "Gamiflow" topic was 2.07 and the maximum overall intrisic motivation was 5.30.

Moreover, the mean overall intrinsic motivation score during the teaching of "Gamiflow" topic was 4.63, which means a satisfactory outcome. Again, as shown in 13, most of the students (60%) presented a high level of intrinsic motivation, followed by medium level of motivation (30%), suggesting that students were intrinsically motivated during the intervention in the "Gamiflow" topic.

IMMS Questionnaire: The internal consistency (Cronbach's alpha) for the Attention (6 items), Relevance (4 items), and Satisfaction (3 items) subscales was greater than .70. Regarding students' motivation level during the teaching of "Gamiflow" topic, as seen in Table 14, the minimum overall motivation level was 2.61 and the maximum overall motivation level was 6.76.

Furthermore, the mean overall motivation level score during the teaching was 4.95, which means a satisfactory outcome. As shown in Table 15, following the previous results, most of the students (50%) presented a high intrinsic motivation level, followed by medium motivation level (40%), which might indicate that students were motivated during the intervention in the "Gamiflow" topic.

8.3 Discussion

In this case study, the main objective was to investigate the effects of teachers' use of the gamification analytics model tool on students' learning outcomes, engagement and motivation. To this end, we used the GamAnalytics tool (a tool implemented based on gamification analytics model for teachers) connected to a gamified educational environment, the Avance, in a real educational scenario.

After collecting and analyzing the collected data in this case study in two topics, the results found might suggest that there is positive evidence that the GamAnalytics tool used integrated with a gamified learning environment such as Avance has the potential to increase

student engagement, learning outcomes and motivation.

These results are of utmost importance since it also shows that teachers may be active users of gamified learning systems with the aid of gamification analytics. As teachers monitor and adapt gamification according to how students or groups of students interact with an learning system, teachers might be much more effective to make pegadogical decisions that are informed by gamification analytics.

However, the present study had some limitations. The first limitation of the study is concerning the limited sample size. According to the literature, the small sample size may guide the production of not useful results (LENTH, 2001) (SCHANZENBACH, 2012). Furthermore, due to the limited sample size of the research, a case study was performed, instead of a controlled experiment, a formal, rigorous and controlled investigation (WOHLIN et al., 2012) that provides more reliable evidence about the research hypotheses (DERMEVAL, 2017). Consequently, considering that one of the disadvantages of case studies is that the results are difficult to generalize (WOHLIN et al., 2012), the reported outcomes of this study could no be securely generalized to other learning environments.

In addition, considering that the level of control is lower in a case study than in an experiment (WOHLIN et al., 2012), it is not possible to assure that the positive results achieved in the case study are due to the use of the gamification analytics model by teachers through the GamAnalytics tool or due to the gamification of the Avance platform. To minimize it, the case study only started to be conducted after 3 months of course. This means that students were already interacting with the platform before and thus had already been exposed to the effect of gamification. Therefore, the possibility of the results achieved in the case study being due to gamification or the novelty effect of it is diminished, suggesting that the effects may have been caused by the use of the proposed model.

Moreover, in order to evaluate students‘ learning outcomes, the present study investigated the short-term retention of the two topics learned during the learning process. It is likely that a long-term evaluation could promote a more reliable understanding of the effect of the intervention on students‘ learning outcomes. Therefore, in order to confirm the results reported in this study, future work should be conducted through a controlled experiment and with a greater concern in choosing an effective sample size and study duration in order to increase the safety and reliability of the results obtained.

9 CONCLUSION, LIMITATIONS AND FUTURE WORKS

In this dissertation, it was pointed out that there are studies in the literature that did not achieve the expected results with the inclusion of gamification in technology-enhanced learning environments concerning students' engagement, motivation and learning outcomes. In order to avoid these unexpected results, a possible approach is to monitor and adapt the gamification design when the expected objectives are not being achieved. Considering that teachers are of utmost importance to the success of education, and we are entering in an era where data is being more used in the service of human decision-making than automated adjustment (BAKER, 2016), teachers could be responsible to monitor and adapt gamification design in gamified learning systems.

The objective of this dissertation was to propose a solution that can be used by teachers that adopt gamified learning systems in order to allow them to adapt the gamification design during the study process based on the monitoring of students' interaction with learning resources and gamification elements in an intuitive, meaningful, enjoyable and effortless way. Therefore, the first contribution of this dissertation is the "Gamification Analytics Model for Teachers". In this model, teachers are allowed to define interaction goals, monitor students' interaction with the system' learning resources and gamification elements, and adapt the gamification design when they judge necessary through the use of missions to motivate students to achieve the interaction goals.

However, future technologies that will adopt the "Gamification Analytics Model for Teachers" need to implement model-based design concepts in the system that correspond to teachers' needs. Therefore, in order to validate these design concepts, it was used the "Speed Dating" method to understand the teachers' needs in gamified learning systems. The second contribution of this dissertation was the validation of 20 design concepts evaluated by teachers through the adoption of the "speed dating method".

In order to view the model from a computational point of view, a gamification analytics model-based tool, GamAnalytics, was developed and integrated into a gamified educational environment, Avance. During the implementation of the proposed tool, the most well-rated design concepts validated by teachers in the speed dating research were introduced in the GamAnalytics. After the implementation of the GamAnalytics tool, a research was conducted with teachers, the tool's target audience, in order to validate the GamAnalytics. As one of the objectives of this dissertation is to develop a tool based on the gamification analytics model for teachers that can be used in an intuitive, meaningful, enjoyable and effortless way, this research, adopting a mixed research method, intended to evaluate the GamAnalytics tool

regarding perceived usefulness, perceived ease of use, behavioral intention, relevance, perceived enjoyment, and self-efficacy constructs, as well as verify the credibility of the tool and its positive and negative points according to teachers. The study showed that most of the teachers' perceptions concerning the GamAnalytics tool were positive.

Furthermore, a case study was conducted to explore the impact of teachers' use of the gamification analytics model through the GamAnalytics tool on students' learning, engagement, and motivation. The case study was conducted in January 2020 with students of the Federal University of Alagoas who were enrolled in the *"Gamification in Education"* course. The case study lasted for four weeks, which was the expected time for students to master the topic "Framework, models and processes" and the topic "Gamiflow". After the conduction of the case study, the collected data of the two topics were investigated and analyzed. The results found might suggest that there is positive evidence that teachers' use of the gamification analytics model through the GamAnalytics tool impact on students' learning and engagement in the two topics taught. Furthermore, students also presented a relevant level of motivation during both topics.

Nonetheless, this work presents some limitations and possibilities for future work. The implementation of the proposed model through the development of the GamAnalytics tool was strongly influenced by the environment into which it was integrated, the Avance gamified educational platform. Therefore, this can cause difficulties in integrating the GamAnalytics tool with other gamified educational environments, due to the difference in the features of the new environments (e.g. gamification elements used, level of teachers' authoring) and/or incompatibility of technologies.

In addition, the case study conducted in this dissertation also presented some limitations concerning to the number of students who participated. There were a total of 20 students enrolled in the "Gamification in Education", but only 10 students participated in all steps of the research. According to (SCHANZENBACH, 2012), the small sample size may guide to underpowered studies, and as a result, some potentially important interventions may be neglected. Moreover, Koivisto and Hamari (KOIVISTO; HAMARI, 2019) states that studies with limited duration for data gathering take an elevated risk of skewing findings by the novelty effects. Another limitation faced concerning the conduction of the case study was due to the impossibility of students receive the missions created by teachers through the Avance platform. This limitation was due to the impossibility of making changes directly in the Avance tool, so the missions were received by email and performed in Avance and the rewards were extra grade in the course.

Moreover, due to the limited sample size, it was not possible to conduct a controlled experiment, so the research design was planned as a case study. Therefore, in future works, in order to better investigate the impact of teachers' use of the gamification analytics model through the GamAnalytics tool on students' learning, engagement, and motivation, a controlled

experiment with an effective sample size and study duration should be conducted in order to increase the safety and reliability of the results obtained, considering that assessments using control groups provide more reliable and accurate evidence on specific research hypotheses.

In future works, an objective is to analyze students‘ interaction with learning resources and gamification elements of the gamified educational environment to predict when students are at risk of failure in order to inform the teacher the best time to apply a mission and also indicate which are the best resources to compose the missions to revert the students' failure status. Additionally, it also aims to assess the difference of automated missions and missions created by teachers in relation to the impact on students in gamified educational environments.

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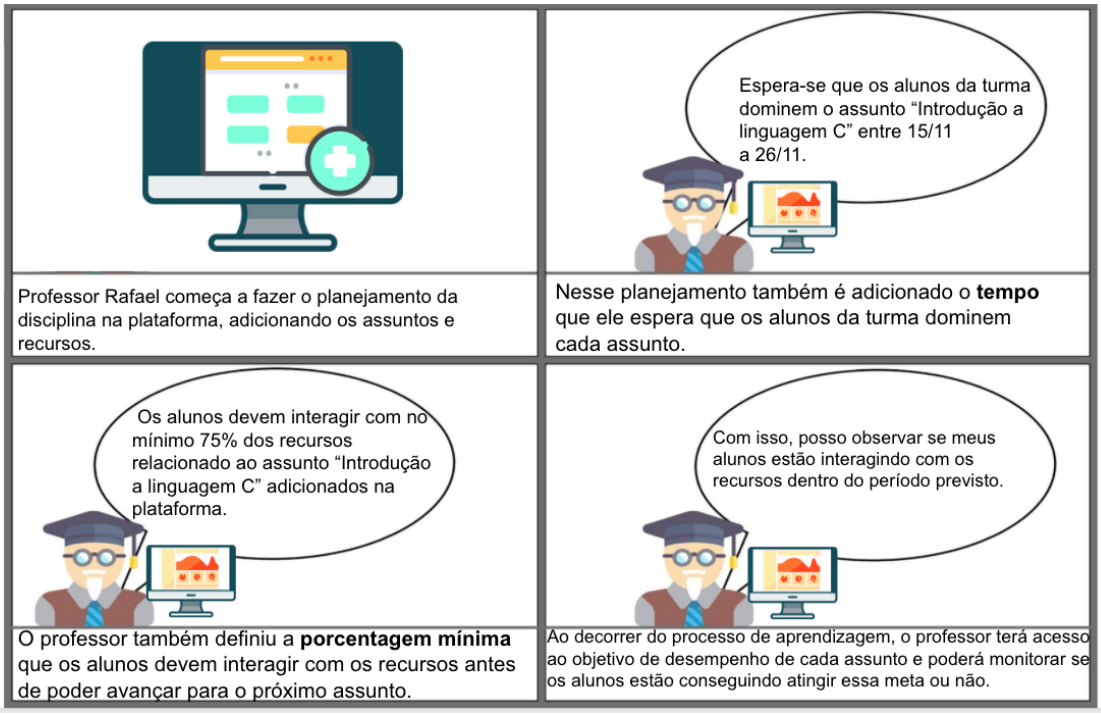
Appendix

APPENDIX A – DESIGN CONCEPTS - SPEED DATING METHOD

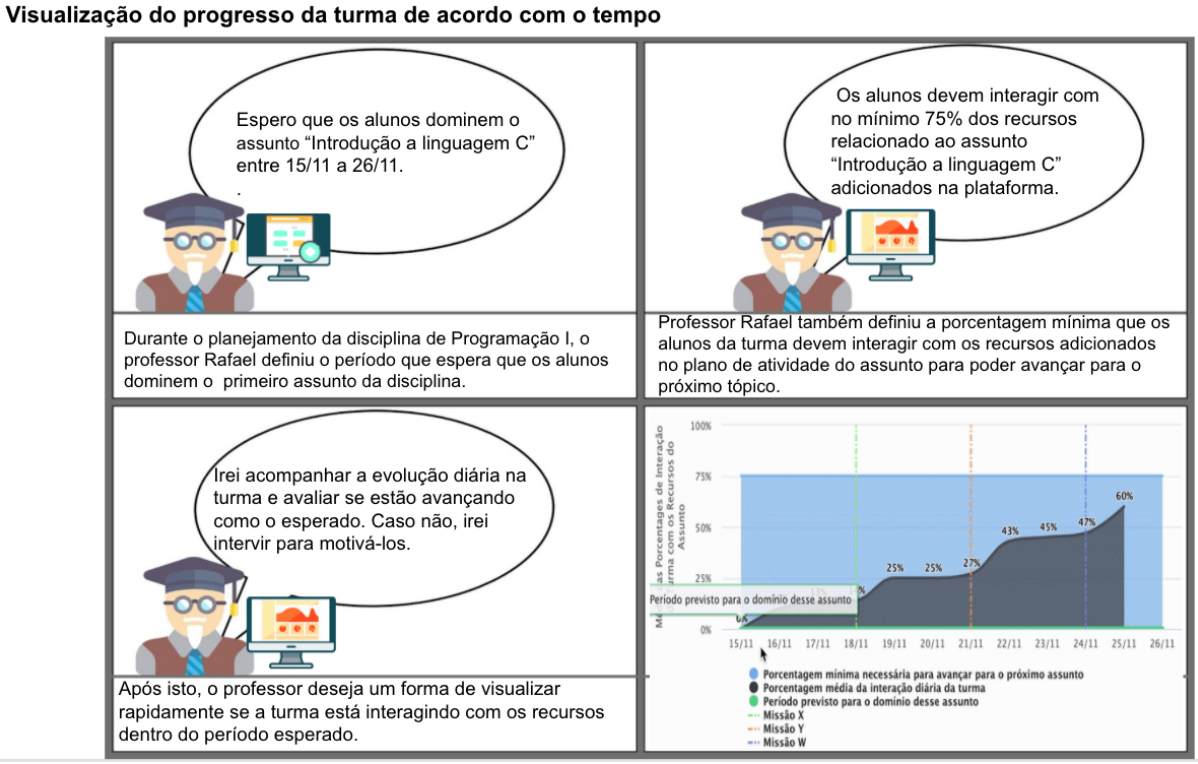
Figure 35 – **Storyboard: Design concept 1**

Definição de objetivos de interação por assunto.



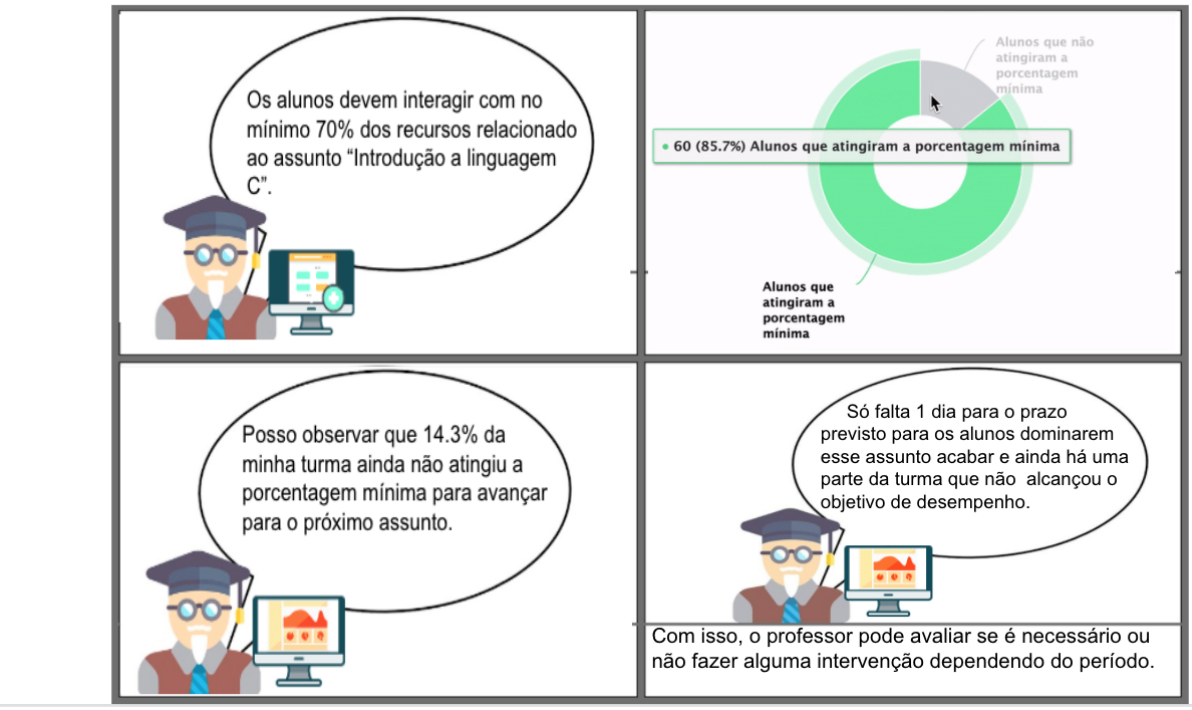
Picture Source: Author

Figure 36 – **Storyboard: Design concept 2**



Picture Source: Author

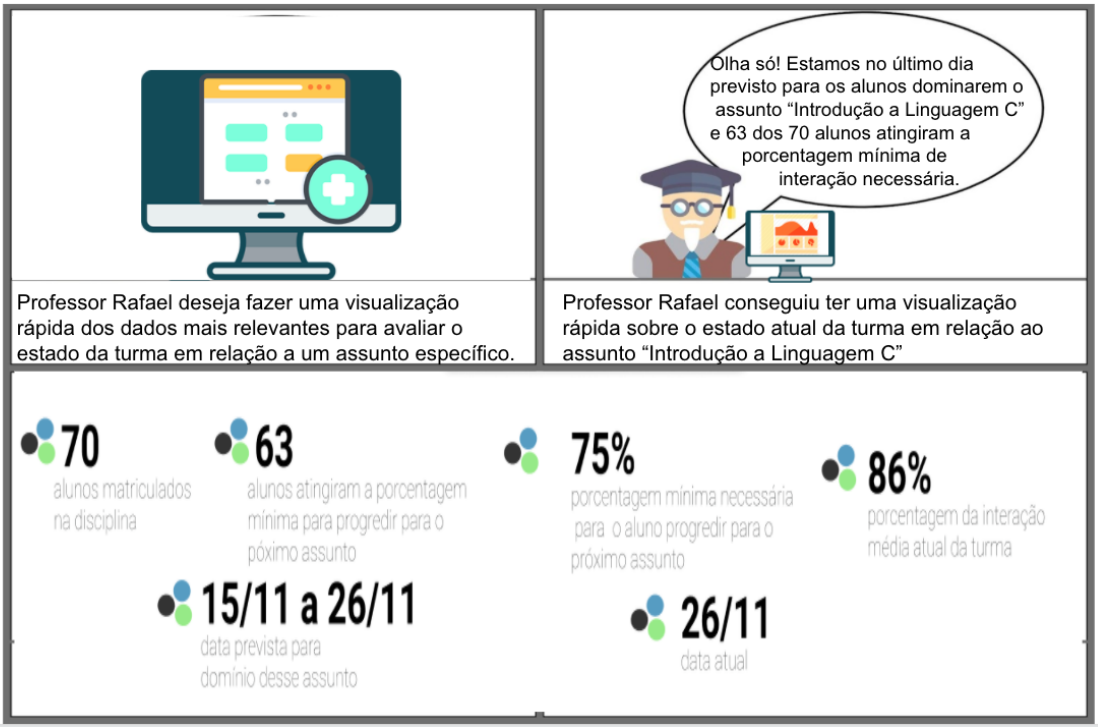
Figure 37 – **Storyboard: Design concept 3**



Picture Source: Author

Figure 38 – **Storyboard: Design concept 4**

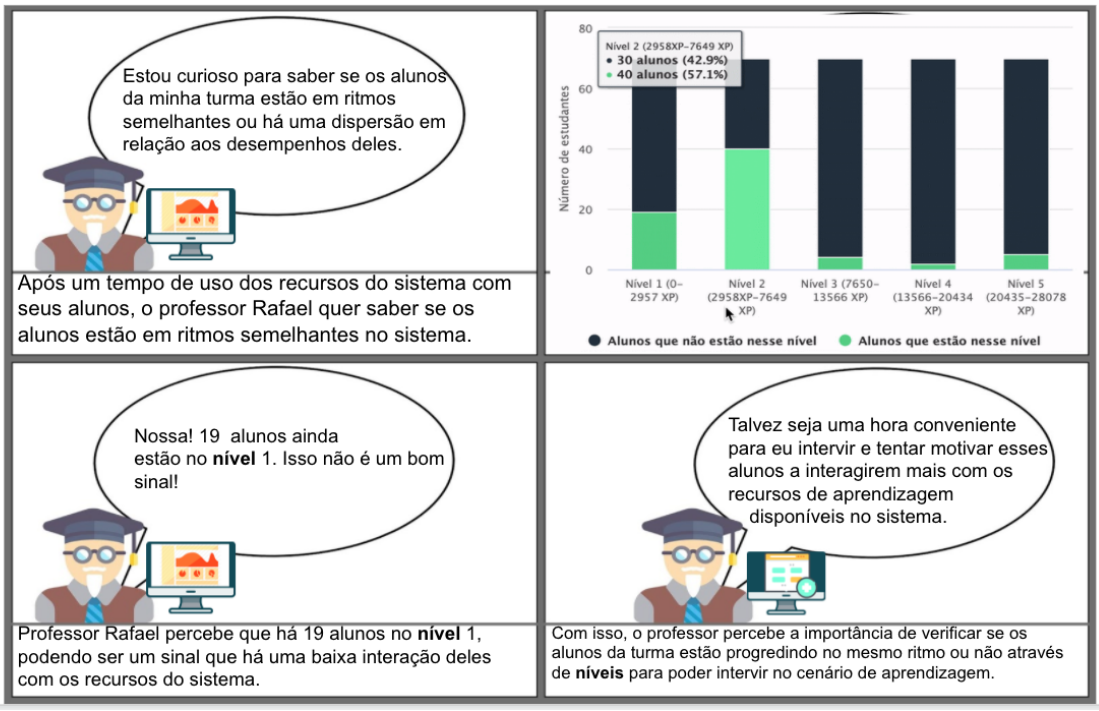
Visualização de dados descritivos da turma



Picture Source: Author

Figure 39 – **Storyboard: Design concept 5**

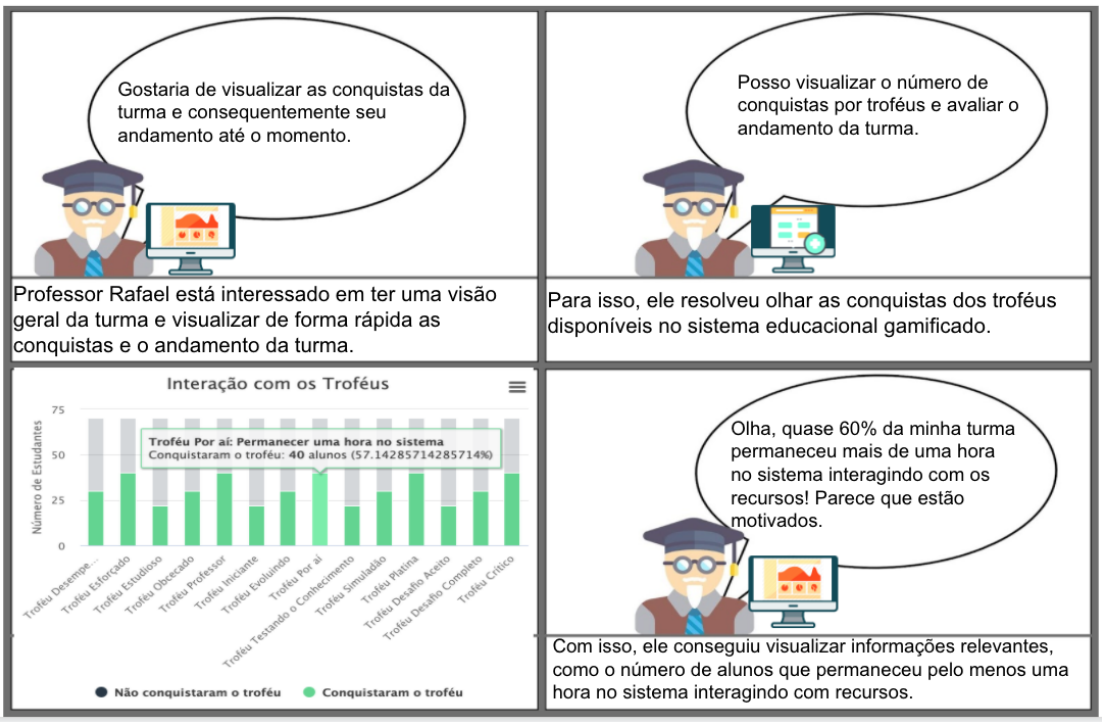
Visualização da distribuição da turma por níveis.



Picture Source: Author

Figure 40 – **Storyboard: Design concept 6**

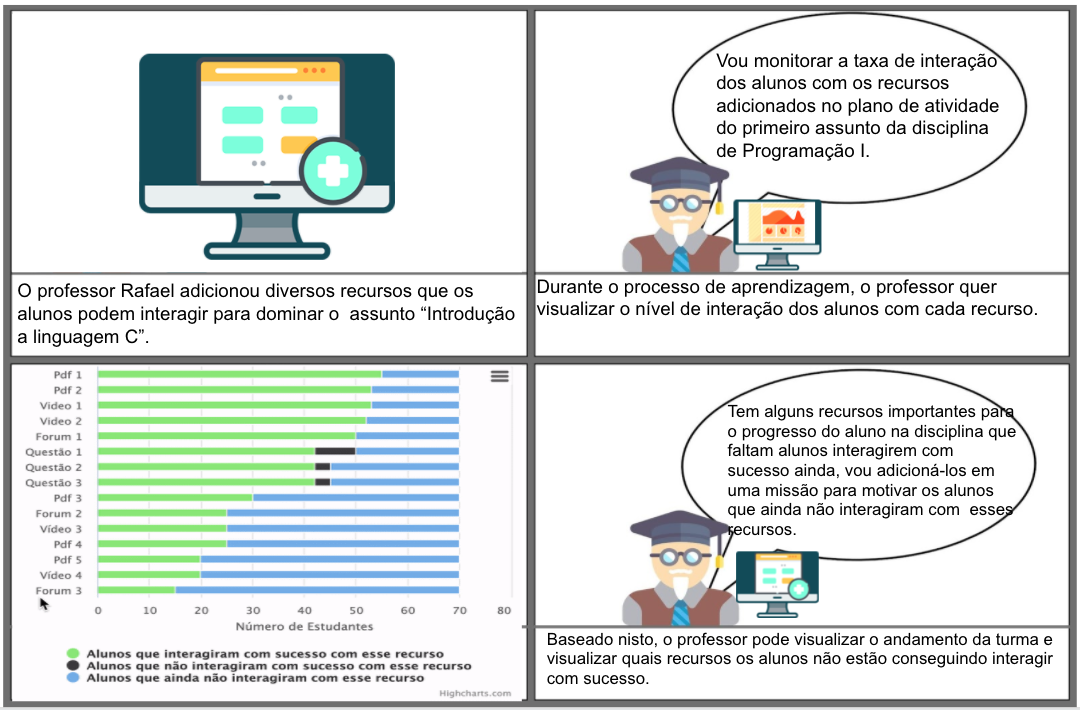
Visualização do número de estudantes que conquistou cada troféu.



Picture Source: Author

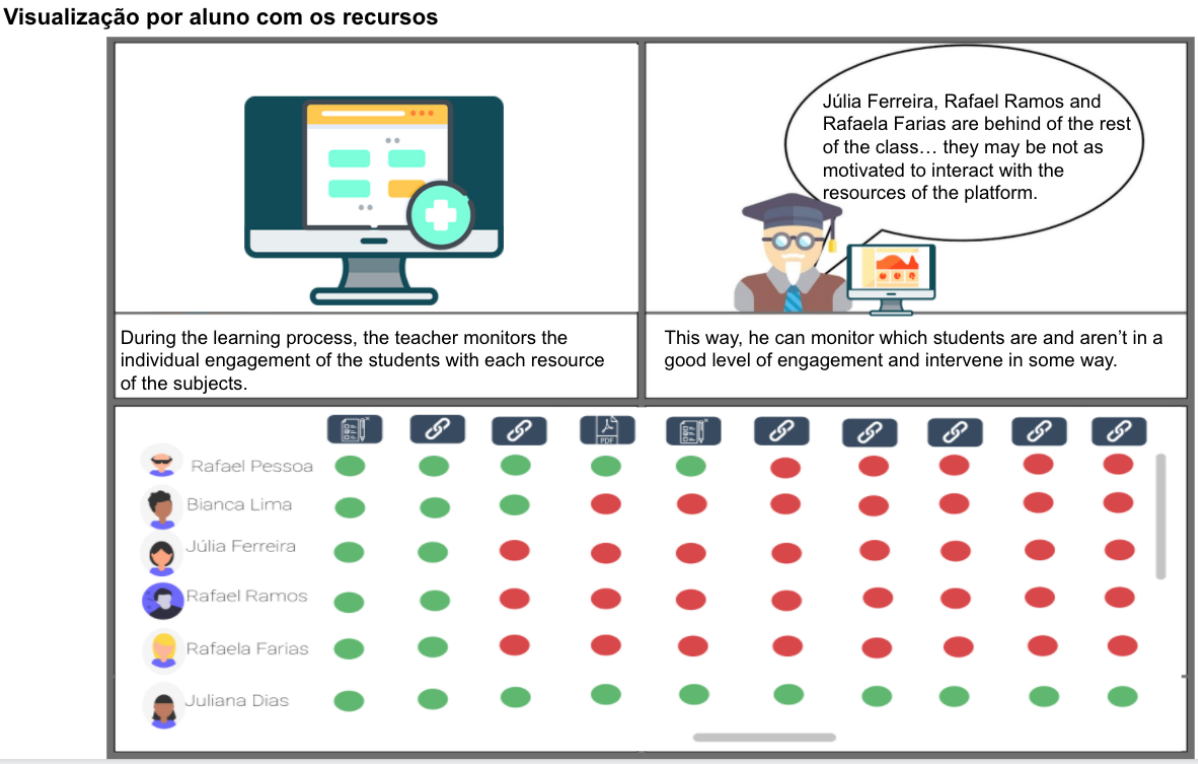
Figure 41 – **Storyboard: Design concept 7**

Visualização da interação dos estudantes com os recursos de cada assunto.



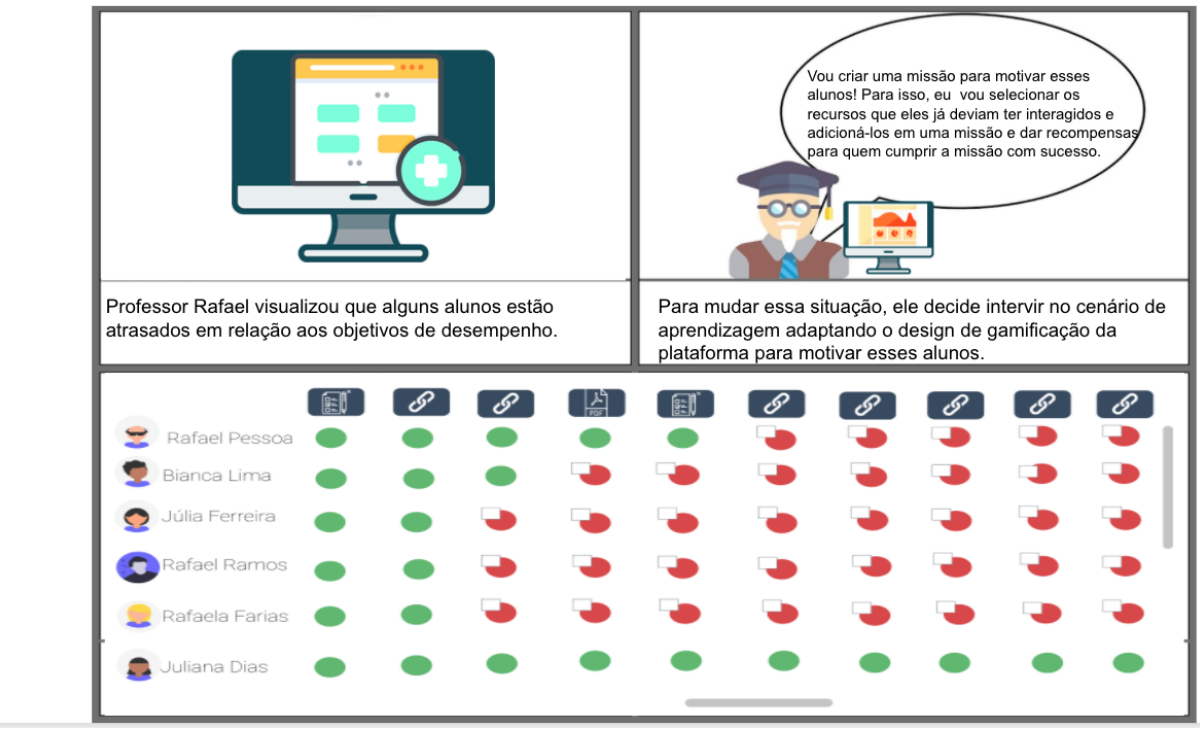
Picture Source: Author

Figure 42 – **Storyboard: Design concept 8**



Picture Source: Author

Figure 43 – **Storyboard: Design concept 9**

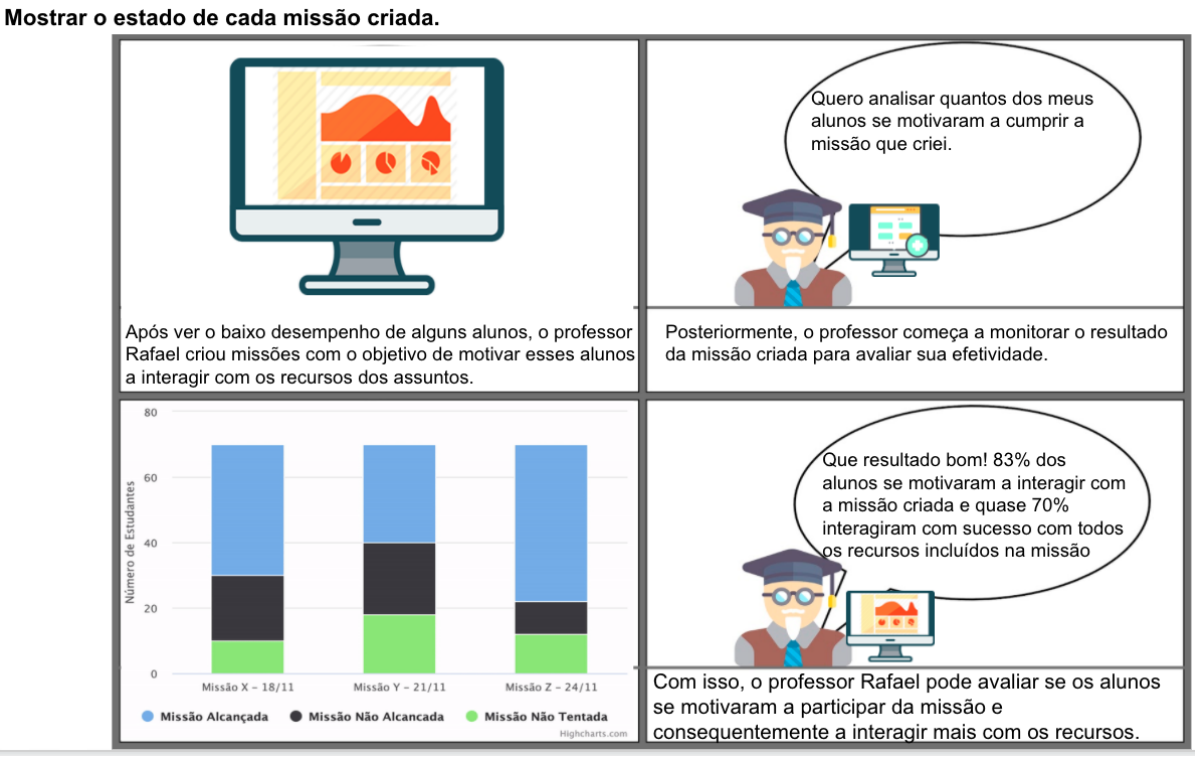


Picture Source: Author

Figure 44 – **Storyboard: Design concept 10**

Picture Source: Author

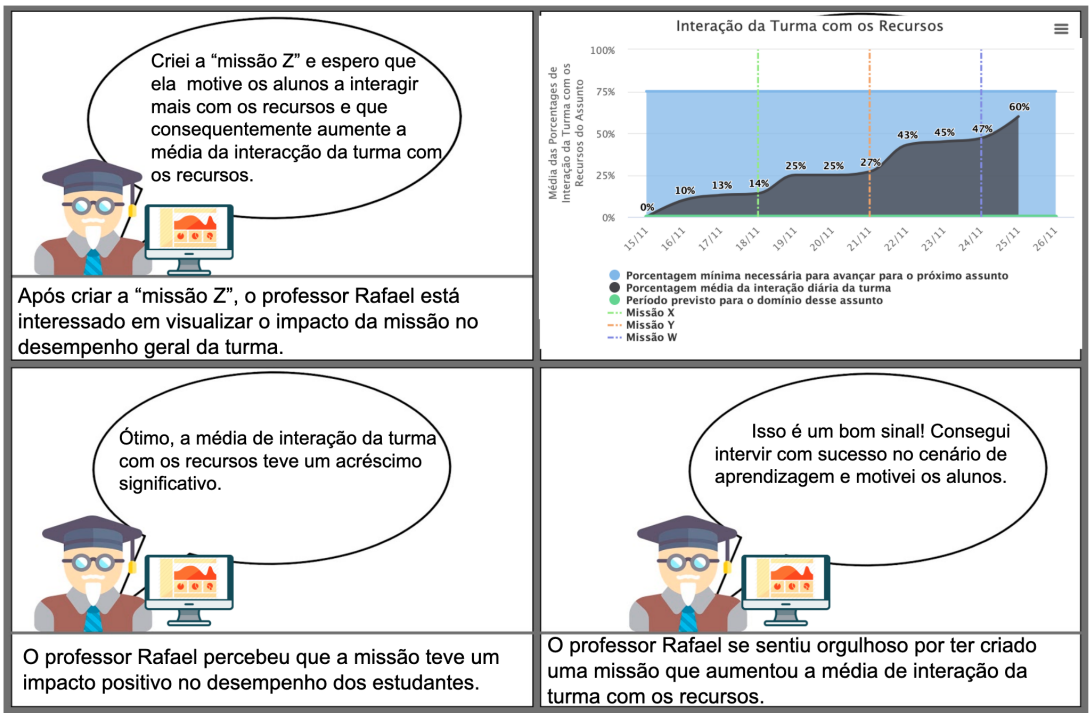
Figure 45 – **Storyboard: Design concept 11**



Picture Source: Author

Figure 46 – **Storyboard: Design concept 12**

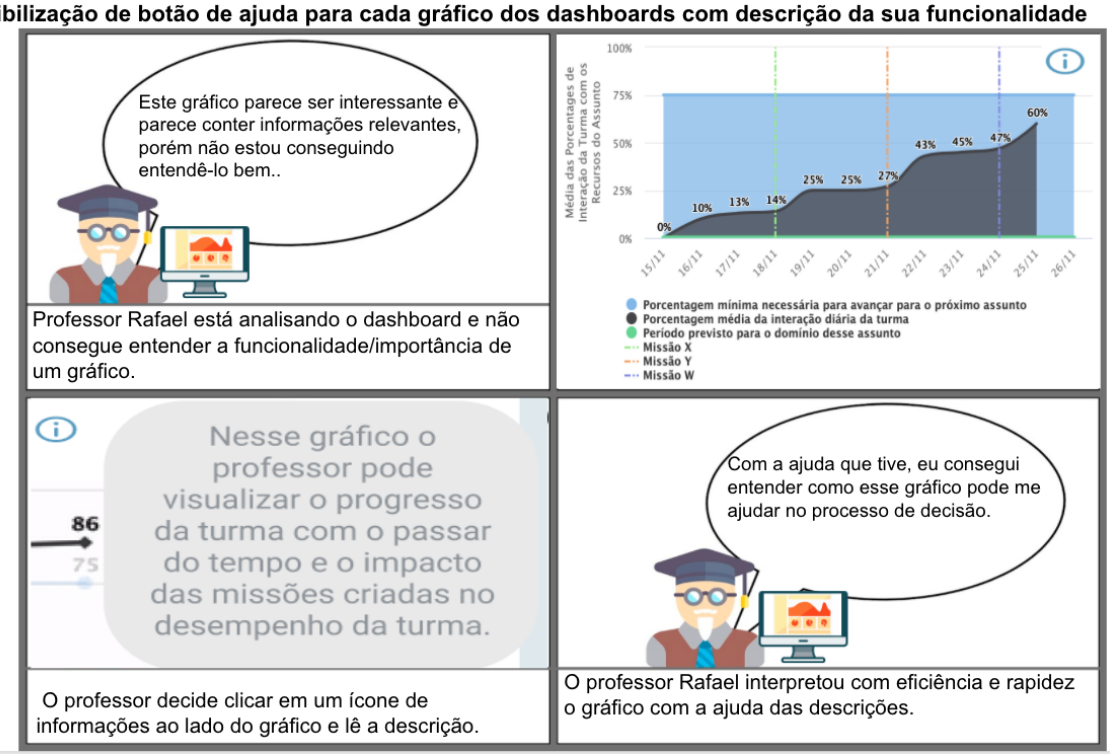
Mostrar o impacto de cada missão na interação geral da turma.



Picture Source: Author

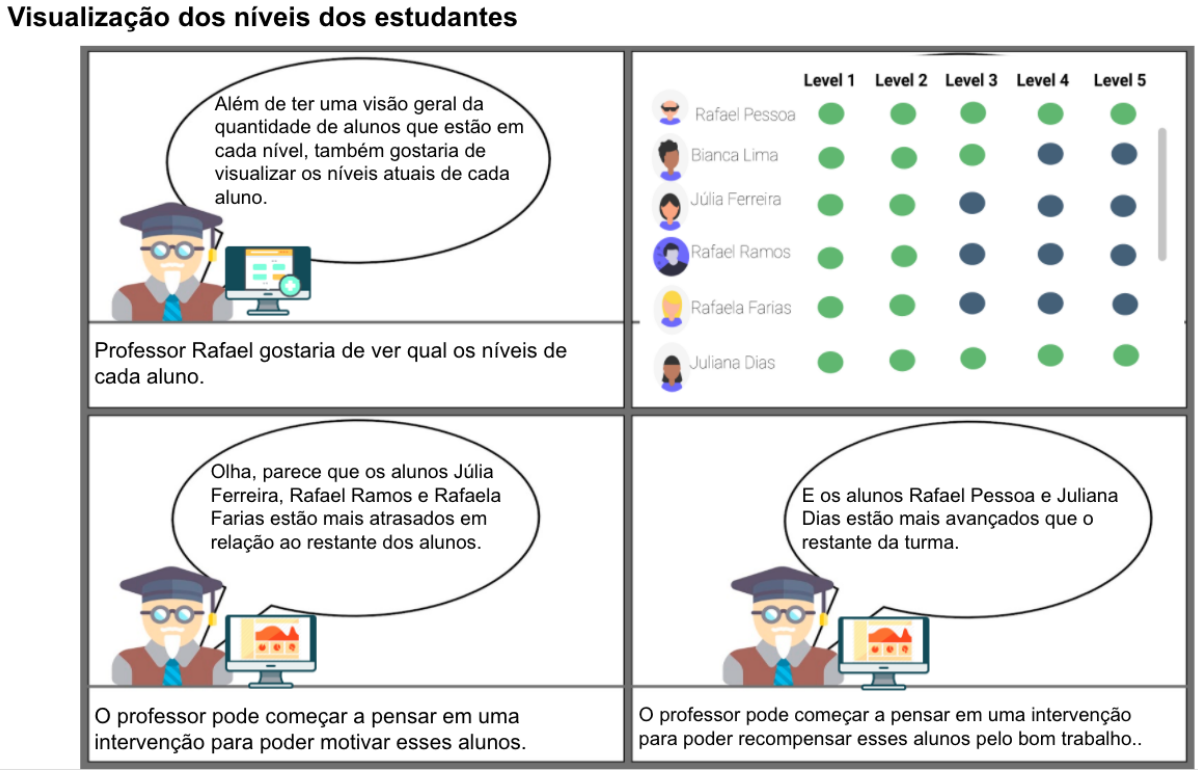
Figure 47 – **Storyboard: Design concept 13**

Disponibilização de botão de ajuda para cada gráfico dos dashboards com descrição da sua funcionalidade



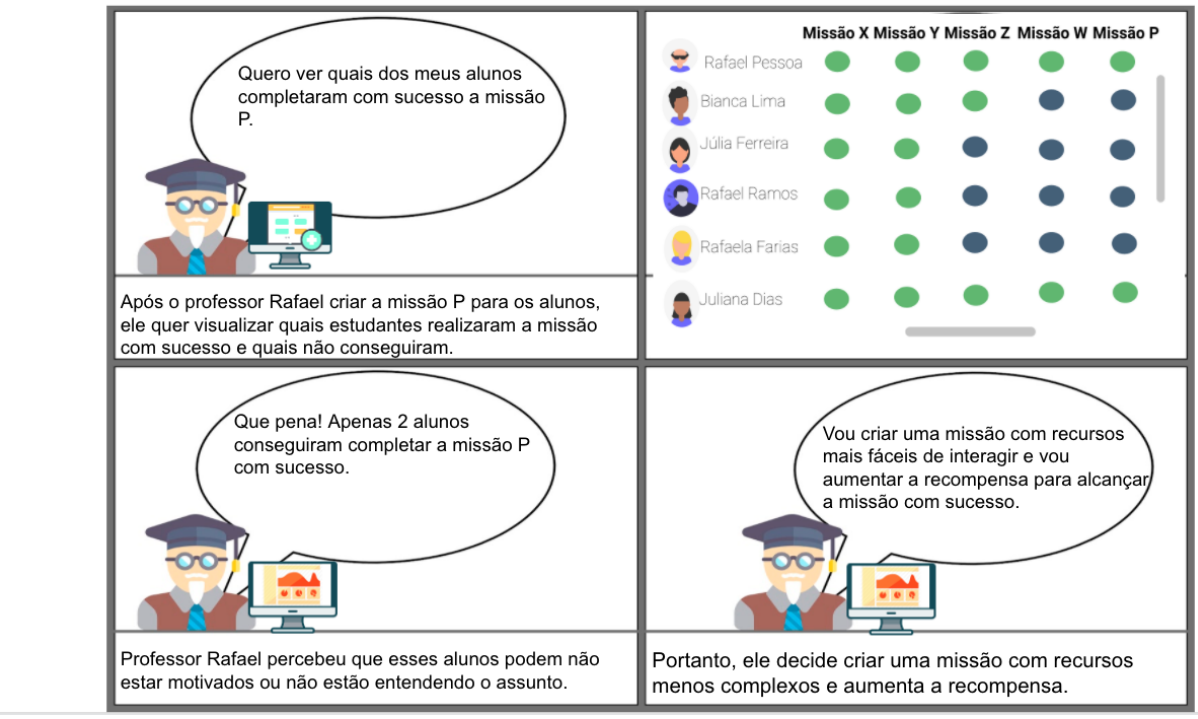
Picture Source: Author

Figure 48 – **Storyboard: Design concept 14**



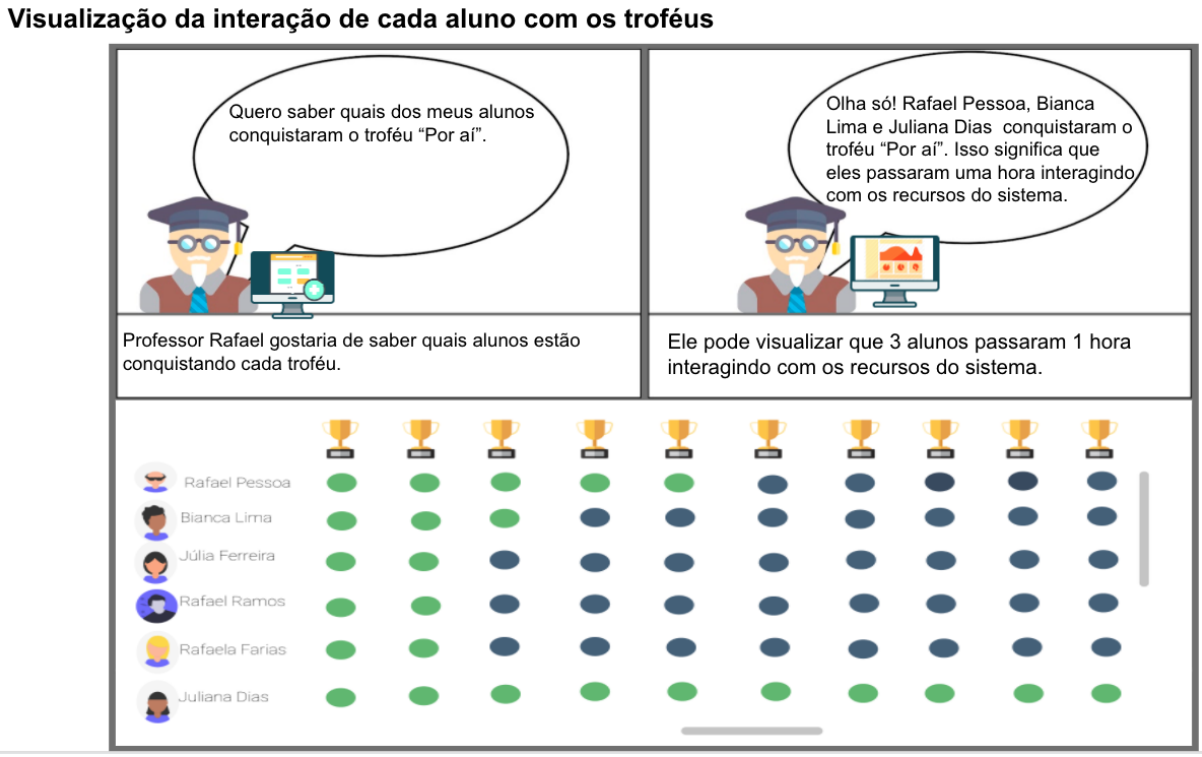
Picture Source: Author

Figure 49 – **Storyboard: Design concept 15**



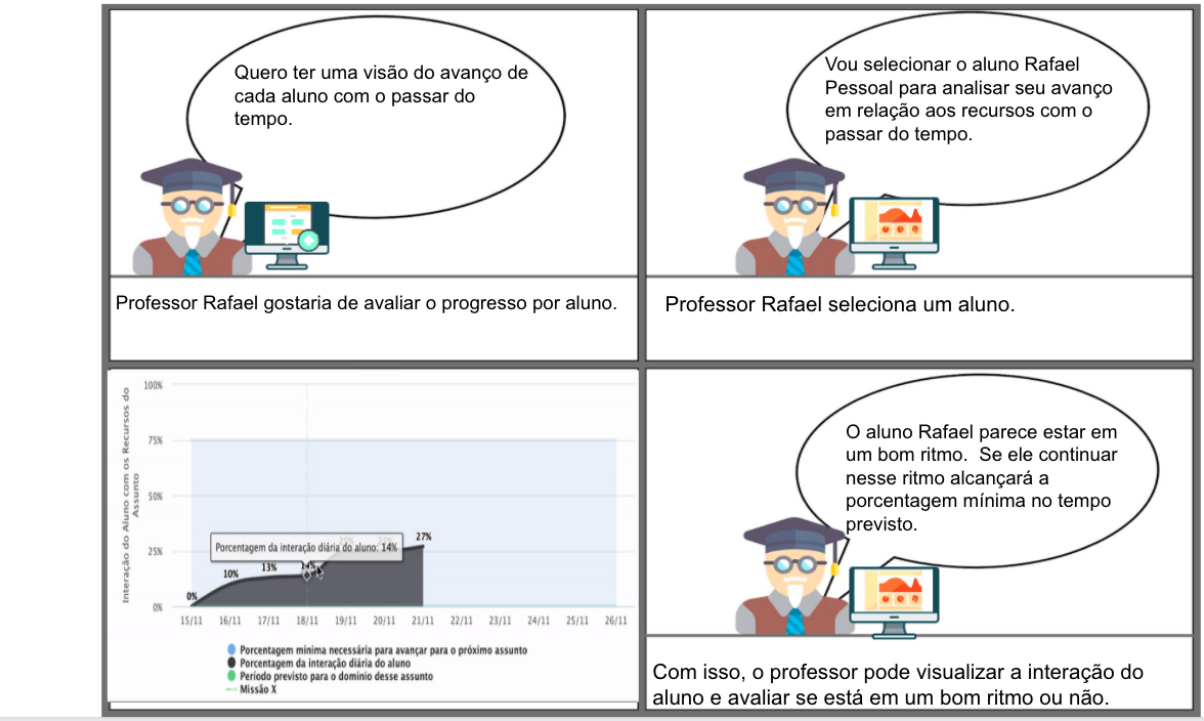
Picture Source: Author

Figure 50 – **Storyboard: Design concept 16**



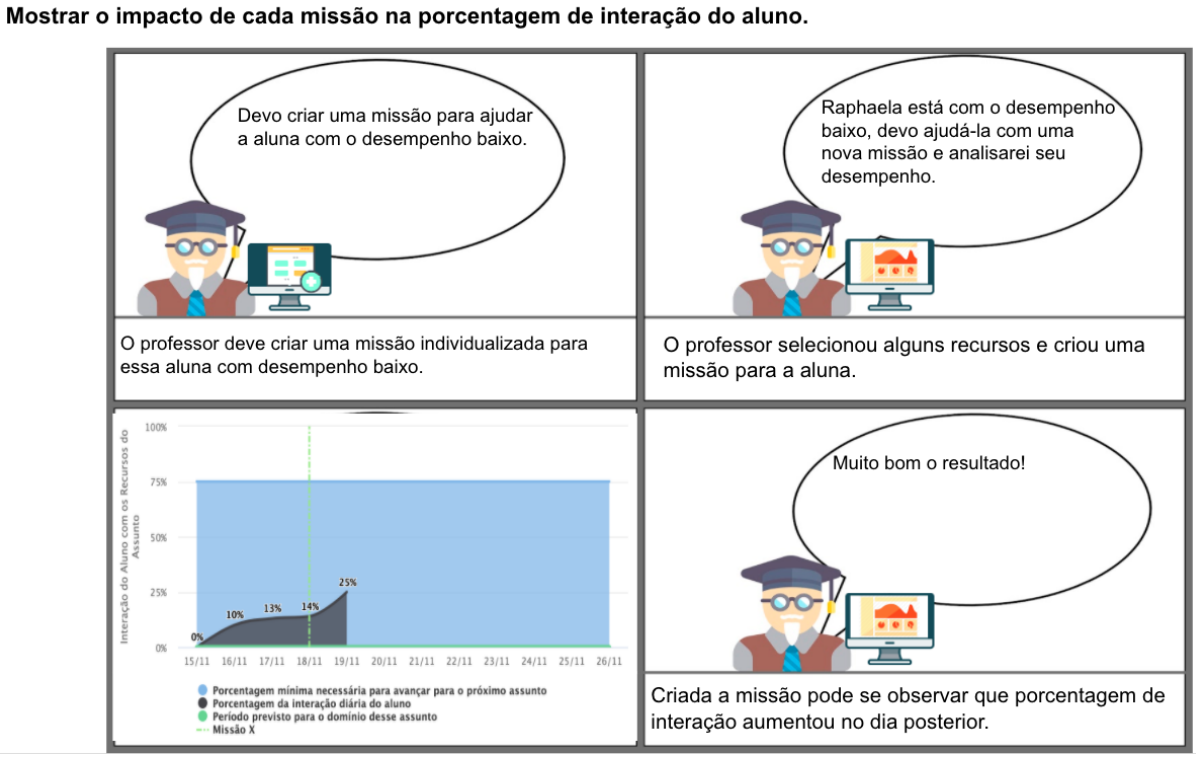
Picture Source: Author

Figure 51 – **Storyboard: Design concept 17**



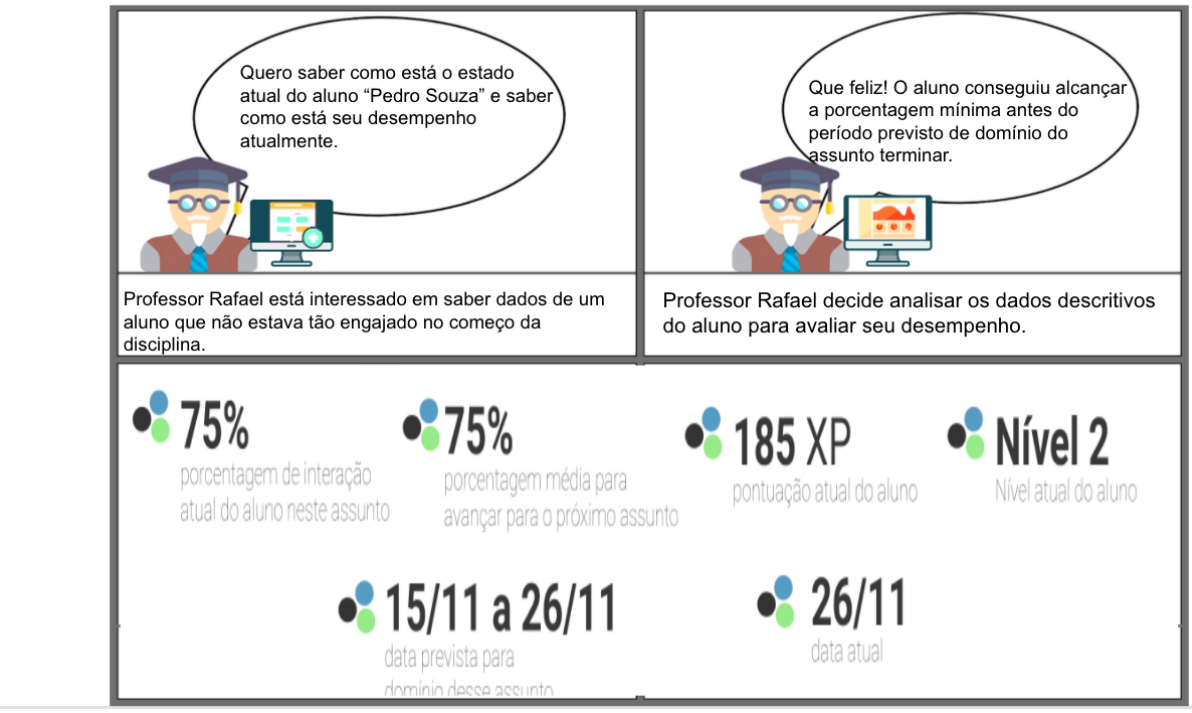
Picture Source: Author

Figure 52 – **Storyboard: Design concept 18**



Picture Source: Author

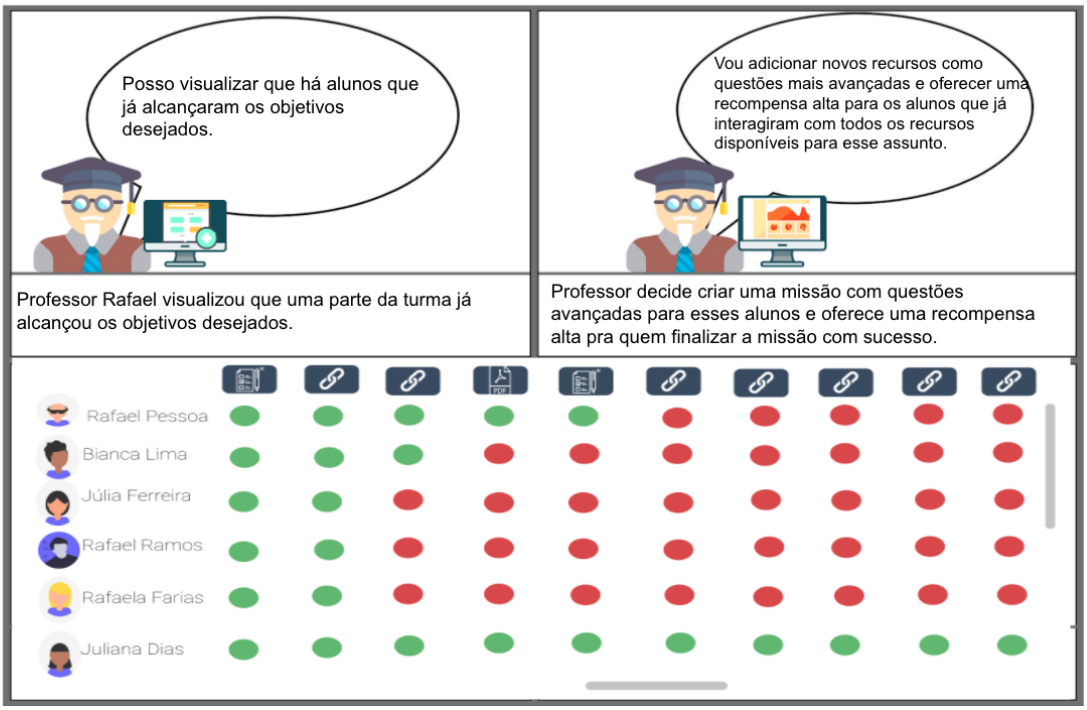
Figure 53 – **Storyboard: Design concept 19**



Picture Source: Author

Figure 54 – **Storyboard: Design concept 20**

Criação de missões para alunos com bom desempenho



Picture Source: Author

APPENDIX B – DEMOGRAPHIC QUESTIONNAIRE

1. Qual a sua idade?

2. Qual o seu sexo?

3. Qual o seu nível de escolaridade?

4. Qual é a sua área de formação?

APPENDIX C – PRE-TEST

Assunto: Frameworks, Modelos e Processos

Questões elaborados baseada na taxonomia de Bloom revisada

1.Como você descreveria os elementos de jogos "Dinâmicas, Mecânicas e Componentes", segundo Werbach e Hunter?

a. Dinâmicas são elementos abstratos, o "big picture", os aspectos que devem ser considerados e gerenciados, mas que não estão diretamente na aplicação.

b. Mecânicas são elementos abstratos, o "big picture", os aspectos que devem ser considerados e gerenciados, mas que não estão diretamente na aplicação.

c. Componentes são elementos abstratos, o "big picture", os aspectos que devem ser considerados e gerenciados, mas que não estão diretamente na aplicação.

d. Dinâmicas são os processos utilizados para incentivar a ação e gerar engajamento. e. Dinâmicas são as instanciações das mecânicas e dinâmicas.

2.Qual seria uma diferença crucial entre os frameworks Octalysis e o 6D?

a. Octalysis é um framework sequencial enquanto que o 6D é um framework não sequencial, ambos classificam os elementos de jogos de forma diferente e também têm propósitos distintos.

b. Octalysis é um framework não-sequencial enquanto que o 6D é um framework sequencial, ambos classificam os elementos de jogos de forma diferente, ambos têm propósitos similares.

c. O Octalysis é um framework composto por 8 etapas onde é focado a implementação dos elementos de jogos, chamados de componentes, divididos em 5 sub níveis distintos.

d. O 6D é um framework composto por 6 etapas, onde em uma delas é focado o empoderamento de criatividade e o feedback.

e. O 6D é um framework composto por 6 etapas, onde em uma delas é focado o empoderamento de criatividade e o feedback.

3. Como você identificaria os perfis de jogadores?

a. Através de informações sobre o perfil demográfico (idade e gênero) ou psicográfico (baseado em valores e personalidades).

b. Através de informações sobre o perfil demográfico (idade e gênero) ou estados de motivação instantâneo.

c. Através de informações sobre o perfil apenas demográfico (idade e gênero).

d. Através de informações sobre o perfil apenas psicográfico (baseado em valores e personalidades).

e. Através de informações sobre o perfil apenas através de estados de motivação instantâneo.

4. O que você pode deduzir sobre o framework de Werbach Hunter (chamado de 6D)?

a. É um framework específico para educação, sequencial e iterativo.

b. É um framework genérico, sequencial e iterativo.

c. É um framework específico para educação baseado na Teoria da Motivação.

d. É um framework baseado na Teoria do Fluxo.

e. Nenhuma das anteriores.

5. Qual seria o possível resultado se a gamificação fosse aplicada de forma não planejada?

a. Melhoria no desempenho dos alunos.

b. Diminuir a carga de trabalho dos alunos.

c. Aumentar o conteúdo a ser explicado.

d. Melhorar a motivação.

e. Comportamento indesejado.

6. Qual ordem dos passos você seguiria para planejar um design da gamificacão, segundo o framework proposto por Werbach Hunter (2013)?

a. Delinearia o comportamento alvo, definiria os objetivos de negócio, desenvolveria os ciclos de atividade, descreveria os jogadores, aplicaria as ferramentas apropriadas, não esqueceria da diversão.

b. Descreveria os jogadores, aplicaria as ferramentas apropriadas, definiria os objetivos de negócio, delinearia o comportamento alvo, desenvolveria os ciclos de atividade, não esqueceria da diversão.

c. Não esqueceria da diversão, desenvolveria os ciclos de atividade, definiria os objetivos de negócio, delinearia o comportamento alvo, descreveria os jogadores, aplicaria as ferramentas apropriadas.

d. Definiria os objetivos de negócio, delinearia o comportamento alvo, descreveria os jogadores, desenvolveria os ciclos de atividade, não esqueceria da diversão, aplicaria as ferramentas apropriadas.

e. Desenvolveria os ciclos de atividade, definiria os objetivos de negócio, descreveria os jogadores, delinearia o comportamento alvo,não esqueceria da diversão, aplicaria as ferramentas apropriadas.

7.O que você pode classificar como objetivos de negócio, entre as alternativas, de acordo com o framework 6D?

a. Melhorar o engajamento dos alunos entre si.

b. Aumentar o engajamento dos alunos no conteúdo explanado.

c. Fazer com que o aluno faça N perguntas durante a aula.

d. As alternativas "a" e "b" estão corretas.

e. As alternativas "a" e "c" estão corretas.

8. Que conclusões você pode tirar sobre o significado Épico e Vocação, uma das unidades centrais que apoiam o framework de gamificação Octalysis?

a. Baseada no princípio que o indivíduo tem de desenvolver suas habilidades, alcançar a maestria e superar desafios propostos.

b. Baseia-se no princípio de que as pessoas estão realizando uma ação significativa e maior que elas mesmas, ou que foram escolhidas para desempenhar tal ação.

c. É identificado quando os usuários estão engajados em um processo criativo dentro do sistema, onde podem tentar novas ações e combinações.

d. Ocorre quando o indivíduo sente que tem propriedade sobre algo e quer aprimorá-lo, acumulando recursos para tal.

e. Se sustenta no princípio de que o indivíduo quer algo pelo fato de ser raro, exclusivo ou inalcançável.

9. Por que você acha que uso de frameworks para planejar o design da gamificação é importante?

a. Porque apresentam um passo-a-passo para implantação da gamificação.

b. Porque fornecem métodos e ferramentas para auxiliar no design.

c. Porque diminue o risco de obter comportamento indesejado, efeitos declinantes, indiferença e perda de desempenho.

d. Todas as alternativas anteriores estão corretas.

e. Nenhuma das alternativas.

10. Por que você acha que é importante definir os jogadores no planejamento do design da gamificação?

a. Porque é necessário selecionar os elementos de jogos mais apropriados para os diferentes perfis.

b. Porque é importante fazer análise estatística no final do processo.

c. Porque facilita entender como lidar com os jogadores.

d. Porque os jogadores ficam ansiosos para saber qual seu perfil.

e. Todas as alternativas anteriores estão corretas.

APPENDIX D – POST-TEST

Assunto: Frameworks, Modelos e Processos

Questões elaborados baseada na taxonomia de Bloom revisada

1. Qual a alternativa relaciona corretamente os tipos de elementos de jogos?

a. Dinâmicas: troféus, conquistas, avatares, lutas contra chefes, coleções, combate, desbloqueio de conteúdo, presentes, placares, níveis, pontos, missões, grafos sociais, equipes, bens virtuais. Mecânicas: desafios, chance, competição, cooperação, feedback, aquisição de recursos, recompensas, transações, turnos, estados de vitória. Componentes: restrições, emoções, narrativa, progressão, relacionamento.

b. Dinâmicas: troféus, conquistas, avatares, lutas contra chefes, coleções, combate, desbloqueio de conteúdo, presentes, placares, níveis, pontos, missões, grafos sociais, equipes, bens virtuais. Mecânicas: restrições, emoções, narrativa, progressão, relacionamento; Componentes: desafios, chance, competição, cooperação, feedback, aquisição de recursos, recompensas, transações, turnos, estados de vitória.

c. Dinâmicas: restrições, emoções, narrativa, progressão, relacionamento; Mecânicas: desafios, chance, competição, cooperação, feedback, aquisição de recursos, recompensas, transações, turnos, estados de vitória; Componentes: troféus, conquistas, avatares, lutas contra chefes, coleções, combate, desbloqueio de conteúdo, presentes, placares, níveis, pontos, missões, grafos sociais, equipes, bens virtuais.

d. Todas as alternativas anteriores estão corretas.

e. Nenhuma das alternativas anteriores está correta.

2. Quais são as unidades centrais que apoiam o framework de gamificação Octalysis?

a. Significado épico e vocação, desenvolvimento e realização, empoderamento de criatividade e feedback, propriedade e posse, influências sociais e relacionamento, escassez e impaciência, imprevisibilidade e curiosidade, perda e evasão.

b. Definir os objetivos de negócio, delinear o comportamento alvo, descrever seus jogadores, desenvolver os ciclos de atividade, não esquecer da diversão, aplicar as ferramentas apropriadas.

c. Dimensão Quem?, Dimensão "O que?", Dimensão "Por quê?", Dimensão "Quando?", Dimensão "Como?", Dimensão "Onde?", Dimensão "Quanto?".

d. What is being gamified, why is it being gamified, who are the users, how is it being gamified, analytics are set up, tested with users, acted/iterated on feedback, released the solution.

e. Nenhuma das alternativas.

3. Quais dessas sentenças não condiz com uma forma indicada de identificar perfis de jogadores?

a. Através de informações sobre o perfil demográfico (idade e gênero).

b. Através de informações sobre o perfil psicográfico (baseado em valores e personalidades).

c. Através de informações sobre os estados de motivação instantâneo.

d. Todas as alternativas estão corretas.

e. Nenhuma das alternativas está correta.

4. O que você pode dizer sobre a etapa "Não esquecer da diversão" do framework 6 Steps to Gamification?

a. Werbach enfatiza que a diversão é um fator importante.

b. O designer da gamificação precisa enfatizá-la no sistema.

c. É recomendado identificar aspectos de jogos que possam continuar a motivar os jogadores mesmo sem as recompensas.

d. Todas as alternativas anteriores estão corretas.

e. Nenhuma das alternativas anteriores está correta.

5. Por que frameworks, métodos e processos sistemáticos vêm sendo desenvolvidos para apoiar o planejamento da gamificação?

a. Porque estas abordagens são compostas por etapas, sempre sequenciais, que auxiliam o planejamento da gamificação.

b. Porque estudos comprovam que essas abordagens não necessariamente auxiliam no design e execução da gamificação.

d. Porque estas abordagens são compostas por etapas, nem sempre sequenciais, que auxiliam o planejamento da gamificação.

d. Porque os frameworks não são passo-a-passo para implantação da gamificação.

e. Nenhuma das anteriores.

6. Quais frameworks de gamificação genéricos você escolheria para planejar o design de gamificação?

a. Framework for teaching e Backward Design framework.

b. 6 Steps to Gamification(6D) framework e Octalysis framework.

c. Backward Design framework e 6 Steps to Gamification(6D) framework.

d. Backward Design framework e Octalysis framework.

e. Framework for teaching e Octalysis framework.

7. Como você distingue o ciclo de engajamento e o ciclo de progressão na etapa "Desenvolver ciclos de atividade" do framework 6D?

a. O ciclo de engajamento é o que motiva os usuários, é proposta uma atividade, onde o usuário recebe um feedback e este feedback deve engajá-lo. Enquanto que o ciclo de progressão guia os usuários no sistema, de modo que eles atinjam os objetivos principais do mesmo.

b. O ciclo de engajamento guia os usuários no sistema, de modo que eles atinjam os objetivos principais do mesmo. Enquanto que o ciclo de progressão é o que motiva os usuários, é proposta uma atividade, onde o usuário recebe um feedback e este feedback deve engajá-lo.

c. O ciclo de engajamento objetiva medir o nível de engajamento dos usuários com as atividades propostas. Enquanto que o ciclo de progressão objetiva comparar o avanço da turma com o avanço planejado.

d. O ciclo de engajamento objetiva comparar o avanço da turma com o avanço planejado. Enquanto que o ciclo de progressão objetiva medir o nível de engajamento dos usuários com as atividades propostas.

e. Nenhuma das alternativas está correta.

8. Quais inferências você pode fazer sobre o framework Octalysis?

a. Foi proposto por Chou (2012).

b. É considerado um framework para planejamento e análise.

c. É um framework não sequencial.

d. Nesse framework a gamificação é apoiada por 8 unidades centrais.

e. Todas as alternativas anteriores estão corretas.

9. O que você não citaria para defender o uso de frameworks para o planejamento do

design da gamificação?

a. Os frameworks oferecem um passo-a-passo para implantação da gamificação.

b. Os frameworks oferecem métodos e ferramentas para auxiliar no design.

c. Os frameworks oferecem um risco menor de obter comportamento indesejado, efeitos declinantes, indiferença e perda de desempenho.

d. Os frameworks oferecem uma forma mais prolongada para planejar o design da gamificação.

e. Nenhuma das alternativas.

10. Qual informação você usaria para dar suporte a ideia de que é importante descrever os jogadores no planejamento do design da gamificação?

a. Descrever os jogadores é importante para fazer análise estatística no final do processo.

b. Descrever os jogadores é importante para facilitar entender como lidar com os jogadores.

c. Descrever os jogadores é importante para selecionar os elementos de jogos mais apropriados para os diferentes perfis.

d. Descrever os jogadores é importante para porque os jogadores ficam ansiosos para saber qual seu perfil.

e. Todas as alternativas anteriores estão corretas.

APPENDIX E – PRE-TEST

Assunto: Framework para o Design de Gamificação baseado na Teoria do Fluxo, GamiFlow

Questões elaborados baseada na taxonomia de Bloom revisada

1. Como você definiria o termo "problemas de engajamento"?

a. Os problemas de engajamento são os aspectos negativos que atrapalham ou evitam que o público-alvo alcance os objetivos do contexto.

b. Os problemas de engajamento são os aspectos positivos que possibilita que o professor visualize que o público-alvo não está alcançando os objetivos do contexto e faça um intervenção.

c. Os problemas de engajamento são os aspectos negativos que atrapalham ou evitam que o público-alvo não alcance os objetivos do contexto.

d. Todas as anteriores.

e. Nenhuma das anteriores.

2. Como você identificaria problemas de motivação nas interações observadas, com base na teoria de experiência de fluxo?

a. Através da falta de equilíbrio entre habilidade-desafio, falta de metas claras e precisas e falta de feedback imediato e direto.

b. Através da falta de equilíbrio entre habilidade-desafio, falta de paradoxo de controle e falta de concentração e foco.

c. Através da falta de feedback imediato e direto, falta de paradoxo de controle e fatal de metas claras e precisas.

d. Todas as anteriores.

e. Nenhuma das anteriores.

3. O que é experiência de fluxo? a. A experiência de fluxo é o estado emocional no qual a mente e o corpo de uma pessoa são absorvidos pela atividade/tarefa e a pessoa sente um profundo nível de prazer.

b. A experiência de fluxo é o estado físico no qual a mente e o corpo de uma pessoa são absorvidos pela atividade/tarefa e a pessoa sente um profundo nível de prazer.

c. A experiência de fluxo é um estado onde a pessoa se perde e não sabe mais qual a tarefa que estava desempenhando.

d. A experiência de fluxo é um guia de como interagir com as tarefas.

e. Nenhuma das anteriores.

4. Segundo o gamiflow, qual seria o resultado se o público-alvo atingisse as sequências de interações esperadas nas interações observadas?

a. Alcance do comportamento-alvo.

b. Alcance dos objetivos de engajamento.

c. Alcance dos objetivos de motivação.

d. Alcance dos eventos do público-alvo.

e. Nenhuma das alternativas está correta.

5.Como são classificadas as teorias de motivação a partir de aspectos não-cognitivos e cognitivos do indivíduo?

a.Instáveis, temporais, proativas, online.

b. Estáveis, temporais, proativas, offline.

c. Estáveis, temporais, proativas, online.

d. Estáveis, atemporais, proativas, online.

e. Nenhuma das anteriores.

6. O que é correto afirmar em referência à identificação dos perfis de jogadores?

a. Não é necessário utilizar um modelo de tipo de jogador para efetuar a definição dos perfis de jogadores.

b. QPJ-BR é um modelo de tipo de jogador que pode ser utilizado para a definição dos perfis de jogadores.

c. Questionário QPJ-BR é um papel de jogador.

d. É necessário utilizar mais de um modelo de tipo de jogador para efetuar a definição dos perfis de jogadores.

e. QPJ-BR é um modelo de tipo de jogador que não pode ser utilizado para a definição dos perfis de jogadores.

7. Quais são as dimensões usadas para medir problemas de engajamento?

a. Dimensões afetiva, comportamental e do pensamento.

b. Dimensões afetiva, comportamental e cognitiva.

c. Dimensões de atenção, percepção e permanência.

d. Dimensões afetiva, cultural e comportamental.

e. Dimensões cognitiva, afetiva e de observação.

8. No que resulta a fusão da ação e consciência, na etapa de execução, ao utilizar gamificação com base na teoria da experiência de fluxo?

a. desconcentração e perda de foco, paradoxo de controle, perda da autoconsciência, sensação de tempo distorcida.

b. concentração e foco, paradoxo de controle, perda da autoconsciência, sensação de tempo distorcida.

c.desconcentração e perda de foco, paradoxo de controle, perda da autoconsciência, sensação de tempo distorcida.

d. equilíbrio entre habilidade e desafio, metas claras e precisas, feedback imediato e direto.

e. equilíbrio entre habilidade e desafio, concentração e foco, paradoxo de controle.

9. Qual método entre as alternativas pode ser utilizado para a definição da dinâmica que mantém o equilíbrio (DME), dinâmica que evita a frustração DEF (DEF) ou dinâmica que evita o tédio (DET)?

a. Método 100

b. Método 101

c. Método 202

d. Método baseado em jogos

e. Nenhuma das alternativas

10. Quais elementos são usados para definir as interações esperadas no delineamento do comportamento-alvo?

a. público-alvo, entidade envolvida, ação, reação, momento da interação e momento da reação.

b. público-alvo, entidade envolvida, ação, reação, momento da ação e momento da reação.

c. público-alvo, entidade envolvida, ação, reação, momento da interação e momento da interação.

d. público-alvo, entidade envolvida, ação, reação, momento da ação e momento da interação.

e. público-alvo, entidade envolvida, interação, reação, momento da ação e momento da interação.

APPENDIX F – POST-TEST

Assunto: Framework para o Design de Gamificação baseado na Teoria do Fluxo, GamiFlow

Questões elaborados baseada na taxonomia de Bloom revisada

1. Como você definiria o gamiflow?

a. Um jogo baseado na teoria de fluxo para sistemas educacionais.

b.Um jogo baseado na teoria de fluxo para alunos aprenderem conceitos de gamificação.

c. Uma teoria baseado na teoria de fluxo que pode ser utilizada como base para a construção de sistemas educacionais gamificados.

d. Uma teoria baseado na teoria de fluxo que pode ser utilizada como base para a criação de jogos educacionais.

e. Um framework baseado na teoria de fluxo para sistemas educacionais gamificados.

2. Quais são os componentes da experiência de fluxo?

a. desequilíbrio entre habilidade e desafio, metas claras e precisas, feedback imediato e direto, fusão de ação e consciência, concentração e foco, paradoxo de controle, perda da autoconsciência, sensação de tempo distorcida, experiência autotélica.

b. equilíbrio entre habilidade e desafio, metas claras e precisas, feedback imediato e direto, fusão de ação e consciência, concentração e foco, paradoxo de controle, perda da autoconsciência, sensação de tempo distorcida, experiência autotélica.

c. equilíbrio entre habilidade e desafio, metas imprecisas, feedback imediato e direto, fusão de ação e consciência, concentração e foco, paradoxo de controle, perda da autoconsciência, sensação de tempo distorcida, experiência autotélica.

d. equilíbrio entre habilidade e desafio, metas claras e precisas, feedback imediato e direto, fusão de ação e consciência, concentração e foco, paradoxo de controle, ganho da auto-consciência, sensação de tempo distorcida, experiência autotélica.

e.Nenhuma das anteriores.

3. O que significa o termo "papel de jogador"?

a. Papel de jogador é função que o público-alvo assume interagindo com elementos de jogo.

b. Papel de jogador é a funcao específica que um jogador tem no jogo.

c. Papel de jogoador é a funcao que um jogador tem em relacão a dinamicas do jogo.

d. Papel de jogador é a função que o público-alvo assume ao interagir com um elemento de jogo específico.

e. Nenhuma das anteriores.

4. Como você não identificaria problemas de engajamento?

a. Através de interações observáveis entre o "público-alvo" e as "entidades envolvidas" e que afetam os "objetivos do contexto" que não é um jogo.

b. Através de interações observáveis entre o "professor" e os "objetivos de contexto" que não é um jogo e que afetam o "público-alvo".

c. Através de instrumentos auto relatados tais como questionários, entrevistas, protocolos verbais (think-aloud) e relatórios de docentes.

d. Através de instrumentos fisiológicos e neurológicos tais como reconhecimento facial, eye-tracking, mouse tracking e EEG.

e. Através de instrumentos baseados em registro de dados tais como o uso do log do sistema para determinar tempo gasto dos usuários no sistema, número de acessos aos recursos e frequência de acesso.

5. Como você identificaria problemas de motivação nas interações observadas, com base na teoria de experiência de fluxo?

a. Através da falta de equilíbrio entre habilidade-desafio.

b. Através da falta de metas claras e precisas.

c. Através da falta de feedback imediato e direto.

d. Todas as anteriores.

e. Nenhuma das anteriores.

6. Que exemplos você pode dar de questionários que podem identificar perfis de jogadores?

a. Questionário QPJ-BR.

b.Questionário de Yee.

c. Questionário Instrucional Material Motivation.

d. Apenas as alternativas a e b estão corretas.

e. Apenas as alternativas b e c estão corretas.

7. O que é correto afirmar sobre a etapa gamificação de conteúdo?

a. Para cada perfil de jogador é preciso alinhar as dinâmicas de jogo.

b. Para cada perfil de jogador é preciso definir as dinâmicas DME, DEF e DET.

c. Para cada perfil de jogador é o gameplay.

d. Todas as alternativas anteriores.

e. Nenhuma das alternativas anteriores.

8. O que significa as dinâmicas DME, DEF e DET?

a. DME: "dinâmica para manter equilíbrio entre habilidade-desafio", DEF: "dinâmica para evitar a frustração" e DET: "dinâmica para evitar o tédio".

b. DME: "dinâmica para materializar esforço", DEF: "dinâmica para economizar trabalho" e DET: "dinâmica para evitar o tédio".

c. DME:"dinâmica para manter equilíbrio entre habilidade-desafio", DEF: "dinâmica para economizar trabalho" e DET: "dinâmica para evitar o tédio".

d. DME: "dinâmica para materializar esforço", DEF: "dinâmica para evitar a frustração" e DET: "dinâmica para economizar tempo".

e. Nenhuma das anteriores.

9. Qual resultado de uma atividade espera-se ao usar gamificação com base na teoria da experiência de fluxo?

a. equilíbrio entre habilidade e desafio.

b. metas claras e precisas.

c. feedback imediato e direto.

d. fusão de ação e consciência.

e. experiência autotélica.

10. O que não é preciso definir no hora de definir o gameplay?

a. Não é preciso definir os papéis de jogador.

b. Não é preciso definir os indicadores de frustração.

c. Não é preciso definir os indicadores de tédio.

d. Não é preciso definir a forma de mudança de papéis de jogador.

e. Não é preciso definir os objetivos de engajamento.

APPENDIX G – IMI QUESTIONNAIRE

INSTRUÇÕES: Por favor responda as seguintes questões em relação a sua experiência no assunto que você acabou de estudar. Não há respostas certas ou erradas. Pense em como você se sentiu enquanto estava aprendendo o assunto e responda às perguntas usando a escala de classificação abaixo. Para cada pergunta, escolha a resposta que melhor corresponde à sua experiência.

1 - Nada verdadeira para mim
4 - Mais ou menos verdadeira para mim
7 - Totalmente verdadeira para mim

	1	2	3	4	5	6	7
Foi muito descontraído estudar o assunto.							
Senti como se tivesse sido obrigado a estudar o assunto.							
Eu me esforcei muito para estudar o assunto.							
Realmente não tive escolha para estudar (ou não) a atividade.							
Não coloquei muita energia (esforço) para estudar o assunto.							
Senti que não estudei o assunto por vontade própria.							
Gostei muito de estudar o assunto.							
Não me senti nervoso ao estudar o assunto.							
O assunto foi divertido.							
Não me esforcei muito para estudar bem o assunto.							
Eu me senti muito tenso ao estudar o assunto.							
Estudei o assunto porque tinha que estudar.							
Eu me senti ansioso enquanto estudava o assunto.							
Estudei o assunto porque não tinha outra escolha.							
Senti-me pressionado enquanto estudava o assunto.							
Descreveria o assunto como muito interessante.							
Achei o assunto muito agradável.							
Enquanto estava estudando o assunto, refleti o quanto eu gostei.							

APPENDIX H – IMMS QUESTIONNAIRE

INSTRUÇÕES: Por favor responda as seguintes questões em relação a sua experiência no assunto que você acabou de estudar. Não há respostas certas ou erradas. Pense em como você se sentiu enquanto estava aprendendo o assunto e responda às perguntas usando a escala de classificação abaixo. Para cada pergunta, escolha a resposta que melhor corresponde à sua experiência.

1 - Nada verdadeira para mim
4 - Mais ou menos verdadeira para mim
7 - Totalmente verdadeira para mim

	1	2	3	4	5	6	7
Houve algo interessante no início deste assunto que chamou minha atenção.							
O ambiente e os recursos do assunto foram atraentes.							
O assunto foi tão abstrato que foi difícil prender minha atenção.							
O ambiente em que foi executado o assunto pareceu sem graça e desagradável.							
A forma como a informação foi organizada no ambiente ajudou a manter minha atenção.							
O assunto teve coisas que estimularam minha curiosidade.							
Eu realmente gostei de estudar o assunto.							
A quantidade de recursos repetitivos no assunto me causou tédio.							
Os recursos e sua organização no assunto transmitiu a impressão de que valia a pena interagir.							
Aprendi algumas coisas que foram surpreendentes e/ou inesperadas.							
O feedback ou outros elementos fornecidos no assunto, me ajudou a me sentir recompensado pelo esforço.							
A variedade de recursos e coisas no ambiente, ajudou a manter minha atenção na atividade.							
O ambiente e os recursos do assunto foram chatos ou entendiantes.							

APPENDIX I – INFORMED CONSENT FORM (T.C.L.E.) - TEACHER

Você está sendo convidado(a) a participar do projeto de pesquisa "Impacto do modelo de monitoramento e adaptação da gamificação para professores no engajamento, aprendizagem e motivação dos alunos em um ambiente educacional gamificado", dos pesquisadores Kamilla Kemilly Tenório Alves dos Santos e Prof. Dr. Diego Dermeval Medeiros da Cunha Matos. A seguir, as informações do projeto de pesquisa com relação a sua participação neste projeto:

1. O estudo trata-se de uma dissertacao do curso de Mestrado de Modelagem Computacional do Conhecimento da Universidade Federal de Alagoas e objetiva investigar o impacto do modelo de monitoramento e adaptação da gamificação para professores na aprendizagem e motivação dos alunos em um ambiente educacional gamificado.

2. A importancia deste estudo e a de verificar se existe diferenca no engajamento, aprendizagem e motivação dos estudantes devido ao monitoramento e adaptação da gamificação feita por professores.

3. Os resultados que se desejam alcançar são os seguintes: espera-se encontrar um resultado positivo em relação ao engajamento, aprendizagem e motivação dos estudantes devido monitoramento e adaptação da gamificação feita por professores.

4. A coleta de dados começará em 21 de Janeiro de 2020 e terminará em 18 de Fevereiro de 2020.

5. O estudo será feito da seguinte maneira: O professor irá definir o plano de atividade e recursos para cada assunto adicionado na disciplina que será ministrada. Após isso, os alunos irão interagir com o ambiente educacional e simultaneamente o professor irá monitorar o desempenho da turma e sua interação com os recursos de aprendizagem e os elementos de gamificação do sistema. O professor poderá criar missões durante o processo de aprendizagem caso queira intervir no cenário de aprendizagem para motivar os estudantes.

6. A sua participação será nas seguintes etapas: acontecerá em todas as etapas.

7. Os incômodos e possíveis riscos à saúde física e/ou mental poderão estar relacionados ao uso do computador durante o período que o estudo de caso será conduzido. Também existe o risco de quebra de sigilo dos alunos com relação aos dados coletados durante o estudo. No entanto, os dados coletados serão todos anonimizados impedindo a sua identificação.

8. Os benefícios esperados através do uso do modelo de monitoramento e adaptação da gamificação para professores são melhorar o engajamento, aprendizagem e motivação dos alunos durante o período do estudo de caso. Desta forma, espera-se que os benefícios superem os riscos, pois, com esta pesquisa pretende-se promover maior desempenho de aprendizagem para os seus alunos.

9. Você poderá contar com a seguinte assistência: ambiente educacional gamificado avance e sistema GamAnalytics, sendo responsáveis pelo sistema os pesquisadores que irão conduzir esse experimento.

10. Você será informado(a) do resultado final do projeto e sempre que desejar, serão fornecidos esclarecimentos sobre cada uma das etapas do estudo.

11. A qualquer momento, você poderá recusar a continuar participando do estudo e, também, que poderá retirar seu consentimento, sem que isso lhe traga qualquer penalidade ou prejuízo.

12. As informações conseguidas através da sua participação não permitirão a identificação da sua pessoa, exceto para a equipe de pesquisa, e que a divulgação das mencionadas informações só será feita entre os profissionais estudiosos do assunto após a sua autorização.

13.O estudo nao acarretara nenhuma despesa para voce.

14. Você será indenizado(a) por qualquer dano que venha a sofrer com a sua participação na pesquisa (nexo causal).

15. Você receberá uma via do Termo de Consentimento Livre e Esclarecido assinado por todos.

Eu, ..., tendo compreendido perfeitamente tudo o que me foi informado sobre a minha participação no

mencionado estudo e estando consciente dos meus direitos, das minhas responsabilidades, dos riscos e dos benefícios que a minha participação implicam, concordo em dele participar e para isso eu DOU O MEU CONSENTIMENTO SEM QUE PARA ISSO EU TENHA SIDO FORÇADO OU OBRIGADO.

Endereço da responsável pela pesquisa:
Instituição: Universidade Federal de Alagoas
Endereço: Rua Elita Pinto Quintela, 246
Complemento: Cidade Universitária
Cidade/CEP: Maceió-AL / 57073-208
Telefone: 82 987652031

Contato de urgência: Sr(a). Kamilla Tenório
Endereço: Rua Elita Pinto Quintela, 246
Complemento: Cidade Universitária
Cidade/CEP: Maceió-AL / 57073-208
Telefone: 82 987652031

ATENÇÃO: *O Comitê de Ética da UFAL analisou e aprovou este projeto de pesquisa. Para obter mais informações a respeito deste projeto de pesquisa, informar ocorrências irregulares ou danosas durante a sua participação no estudo, dirija-se ao:*

Comitê de Ética em Pesquisa da Universidade Federal de Alagoas

Prédio do Centro de Interesse Comunitário (CIC), Térreo , Campus A. C. Simões, Cidade Universitária

Telefone: 3214-1041 – Horário de Atendimento: das 8:00 as 12:00hs.

E-mail: comitedeeticaufal@gmail.com

Maceió, de de 2019.

Assinatura ou impressão datiloscópica d(o,a) voluntári(o,a) ou responsável legal e rubricar as demais folhas	Nome e Assinatura do Pesquisador pelo estudo (Rubricar as demais páginas)

APPENDIX J – INFORMED CONSENT FORM (T.C.L.E.) - STUDENTS

Você está sendo convidado(a) a participar do projeto de pesquisa "Impacto do modelo de monitoramento e adaptação da gamificação para professores no engajamento, aprendizagem e motivação dos alunos em um ambiente educacional gamificado", dos pesquisadores Kamilla Kemilly Tenório Alves dos Santos e Prof. Dr. Diego Dermeval Medeiros da Cunha Matos. A seguir, as informações do projeto de pesquisa com relação a sua participação neste projeto:

1. O estudo trata-se de uma dissertacao do curso de Mestrado de Modelagem Computacional do Conhecimento da Universidade Federal de Alagoas e objetiva investigar o impacto do modelo de monitoramento e adaptação da gamificação para professores na aprendizagem e motivação dos alunos em um ambiente educacional gamificado.

2. A importancia deste estudo e a de verificar se existe diferenca no engajamento, aprendizagem e motivação dos estudantes devido ao monitoramento e adaptação da gamificação feita por professores.

3. Os resultados que se desejam alcançar são os seguintes: espera-se encontrar um resultado positivo em relação ao engajamento, aprendizagem e motivação dos estudantes devido monitoramento e adaptação da gamificação feita por professores.

4. A coleta de dados começará em 19 de Janeiro de 2020 e terminará em 28 de Fevereiro de 2020.

5. O estudo será feito da seguinte maneira: Primeiramente, os alunos irão responder um questionário demográfico, o formulário QPJ-BR e um pré-teste para avaliar seu conhecimento em relação a cada assunto que será ensinado durante o período do estudo de caso antes de interagir com o ambiente educacional gamificado. Após essa etapa, os alunos irão utilizar o ambiente educacional e eventualmente participar de missões, caso o professor responsável pela disciplina crie alguma durante o período do estudo de caso. No final, os alunos irão fazer um pós-teste de cada assunto para avaliar seu conhecimento em relação ao assunto que aprenderam durante o estudo de caso e preencher dois questionário para avaliar sua motivação durante o período do estudo de caso para cada assunto. No final do estudo de caso, os alunos irão responder um questionário aberto sobre a sua motivação em relação ao cumprimento das

missões.

6. A sua participação acontecerá em todas as etapas.

7. Os incômodos e possíveis riscos à saúde física e/ou mental poderão estar relacionados ao uso do computador durante o período que o estudo de caso será conduzido. Também existe o risco de quebra de sigilo com relação aos dados coletados durante o estudo. No entanto, os dados coletados serão todos anonimizados impedindo a sua identificação.

8. Os benefícios esperados através do uso do modelo de monitoramento e adaptação da gamificação para professores são melhorar o engajamento, aprendizagem e motivação dos alunos durante o período do estudo de caso. Desta forma, espera-se que os benefícios superem os riscos, pois, com esta pesquisa pretende-se promover maior desempenho de aprendizagem para você.

9. Você poderá contar com a seguinte assistência: ambiente educacional gamificado avance, sendo responsáveis pelo sistema os pesquisadores que irão conduzir esse experimento.

10. Você será informado(a) do resultado final do projeto e sempre que desejar, serão fornecidos esclarecimentos sobre cada uma das etapas do estudo.

11. A qualquer momento, você poderá recusar a continuar participando do estudo e, também, que poderá retirar seu consentimento, sem que isso lhe traga qualquer penalidade ou prejuízo.

12. As informações conseguidas através da sua participação não permitirão a identificação da sua pessoa, exceto para a equipe de pesquisa, e que a divulgação das mencionadas informações só será feita entre os profissionais estudiosos do assunto após a sua autorização. Além disso, a sua participação no estudo não valerá nota para a disciplina.

13.O estudo nao acarretara nenhuma despesa para voce.

14. Você será indenizado(a) por qualquer dano que venha a sofrer com a sua participação na pesquisa (nexo causal).

15. Você receberá uma via do Termo de Consentimento Livre e Esclarecido assinado

por todos.

Eu, ..., tendo compreendido perfeitamente tudo o que me foi informado sobre a minha participação no mencionado estudo e estando consciente dos meus direitos, das minhas responsabilidades, dos riscos e dos benefícios que a minha participação implicam, concordo em dele participar e para isso eu DOU O MEU CONSENTIMENTO SEM QUE PARA ISSO EU TENHA SIDO FORÇADO OU OBRIGADO.

Endereço da responsável pela pesquisa:
Instituição: Universidade Federal de Alagoas
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ATENÇÃO: *O Comitê de Ética da UFAL analisou e aprovou este projeto de pesquisa. Para obter mais informações a respeito deste projeto de pesquisa, informar ocorrências irregulares ou danosas durante a sua participação no estudo, dirija-se ao:*

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Maceió, de de 2019.

Assinatura ou impressão datiloscópica d(o,a) voluntári(o,a) ou responsável legal e rubricar as demais folhas	Nome e Assinatura do Pesquisador pelo estudo (Rubricar as demais páginas)

APPENDIX K – LIST OF PAPERS ACCEPTED TO PUBLISH, UNDER EVALUATION AND PAPERS TO SUBMIT

In this section is listed the articles that were produced during the master's period.

The development of this dissertation resulted in 4 scientific articles. (1) The first article are going to be re-submitted to the IEEE Transactions on Learning Technologies (TLT) Journal. Two articles (2) (3) were accepted to be presented in the International Conference on Artificial Intelligence in Education - AIED 2020. (4) The fourth article is being revised to be submitted to a Journal in the Computers and Education research field. In the following, the name of the articles and their status will be described.

1. **Gamification in Collaborative Learning Systems and/or Adaptive Learning Systems in the Educational Context - A Systematic Review:** To be re-submitted to the IEEE Transactions on Learning Technologies (TLT) Journal.

2. **Raising Teachers Empowerment in Gamification Design of Adaptive Learning Systems: A Qualitative Research:** Accepted as a full-paper in the Proceedings of the International Conference on Artificial Intelligence in Education (TENÓRIO et al., 2020b).

3. **Helping teachers assist their students in gamified adaptive educational systems: towards a gamification analytics tool:** Accepted as a short-paper in the Proceedings of the International Conference on Artificial Intelligence in Education (TENÓRIO et al., 2020a).

4. **Monitoring and Adaptation of Gamification Designs by Teachers in Gamified Learning Systems:** To be submitted.

In addition to the articles related to this dissertation, there are two articles developed that are not related to this dissertation. (5) The first has been submitted to the Journal of Computer Assisted Learning and is under review. (6) The second is being revised to be later submitted to a conference in the area of Artificial Intelligence in Education.

5. **Applications of Brain-Imaging Techniques in Educational Technologies Research: A Systematic Literature Review:** Submitted to the Journal of Computer Assisted Learning.

6. **On the joint use of Artificial Intelligence and Brain-Imaging Techniques in Educational Technologies: A Systematic Mapping Study:** To be submitted.