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Contributions for Gamification Design in Educational Contexts

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Tese de Doutorado do Programa de Pós-Graduação em Ciências de Computação e Matemática Computacional (PPG-CCMC)

ICMC USP SÃO CARLOS

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Contributions for Gamification Design in Educational Contexts

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Contribuições para o Design de Gamificação em Contextos Educacionais

Tese apresentada ao Instituto de Ciências Matemáticas e de Computação – ICMC-USP, como parte dos requisitos para obtenção do título de Doutor em Ciências – Ciências de Computação e Matemática Computacional. *VERSÃO REVISADA*

Área de Concentração: Ciências de Computação e Matemática Computacional

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USP – São Carlos
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I dedicate this work to my family,
my friends,
my mentors,
and everyone who was with me during this journey.

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“We’re all stories in the end,
just make it a good one”
(Doctor Who)

RESUMO

TODA, A. M. **Contribuições para o Design de Gamificação em Contextos Educacionais**. 2021. 225 p. Tese (Doutorado em Ciências – Ciências de Computação e Matemática Computacional) – Instituto de Ciências Matemáticas e de Computação, Universidade de São Paulo, São Carlos – SP, 2021.

Este texto apresenta e analisa as contribuições de uma coletânea de artigos referentes as pesquisas realizadas pelo autor e seus colaboradores. Os artigos estão relacionados a área de Gamificação Aplicada à Educação e utilizam três abordagens chaves denominadas, Gamificação na Educação, Planejamento da Gamificação em contextos educacionais e Planejamento da gamificação baseado em dados. Em relação a Gamificação Aplicada à Educação, são apresentados trabalhos teóricos que contribuem para o avanço da área, assim como provem novos artefatos a serem explorados em trabalhos futuros, como uma taxonomia de elementos de gamificação e um modelo de gamificação associado a cultura, ambos em contextos educacionais. No Planejamento da Gamificação em contextos educacionais, o autor demonstra o processo de desenvolvimento e aplicação de um framework conceitual de gamificação, além de práticas de como gamificar contextos educacionais. Já em relação ao Planejamento da Gamificação baseado em dados, as contribuições do autor são focadas no uso de mineração de dados para prover estratégias gamificadas validadas para o uso do professor, além de condições para gamificar contextos educacionais. Por fim, as discussões dos artigos são contextualizadas dentro de perguntas de pesquisa encontradas na literatura, de forma a demonstrar a relevância dos resultados encontrados frente ao estado da arte. O texto também resume as atividades do autor como pesquisador, incluindo (a) uma análise qualitativa e quantitativa dos trabalhos publicados; (b) a participação do autor na comunidade científica nacional e internacional; e (c) reflexões e perspectivas futuras.

Palavras-chave: Gamificação, Planejamento, Modelagem, Educação, Coletânea.

ABSTRACT

TODA, A. M. **Contributions for Gamification Design in Educational Contexts**. 2021. 225 p. Tese (Doutorado em Ciências – Ciências de Computação e Matemática Computacional) – Instituto de Ciências Matemáticas e de Computação, Universidade de São Paulo, São Carlos – SP, 2021.

This text presents and analyzes the contributions of a collection of articles related to research carried out by the author and his collaborators. The articles are related to the fields of Gamification Applied to Education and use three key approaches called Gamification in Education, Gamification Planning in Educational Contexts and Data-Based Gamification Planning. In relation to Gamification Applied to Education, theoretical works are presented that contribute to the advancement of the area, as well as providing new artifacts to be explored in future works, such as a taxonomy of gamification elements and a gamification model associated with culture, both in educational contexts. In Gamification Planning in educational contexts, the author demonstrates the process of developing and applying a conceptual gamification framework, in addition to practices on how to gamify educational contexts. In relation to Gamification Planning based on data, the author's contributions are focused on the use of data mining to provide validated gamified strategies for the use of the teacher, in addition to conditions to gamify educational contexts. Finally, the discussions of the articles are contextualised within research questions found in the literature, in order to demonstrate the relevance of the results found in view of the state of the art. The text also summarises the author's activities as a researcher, including (a) a qualitative and quantitative analysis of published works; (b) the participation of the author in the national and international scientific community; and (c) reflections and future perspectives.

Keywords: Gamification, Planning, Modeling, Education, Collection.

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CHAPTER

1

INTRODUCTION

The increasing and exponential use of electronic games in recent years has attracted the attention of the academic community, who analyses these games in order to verify their applicability and effectiveness in several areas of knowledge. This game market has been influencing several aspects of how users interact with technology, being increasingly intrinsic in the daily lives of these individuals (SCHELL, 2014), especially in the educational field (SHELDON, 2011).

Research in this field has led to the emergence of areas such as digital game based learning, which aims to integrate digital games in the educational context, with a focus on improving student performance and motivation (PRENSKY, 2003). For Prensky, these games are already part of the culture of several countries and the routine of digital natives, being therefore a learning object with several benefits. However, the production and insertion of these games in the academic environment suffers from several controversies, among them we can mention the poor acceptance by teachers, the costs for the development and implementation and the complexity of developing serious and fun games (LEE; HAMMER, 2011; SEABORN; FELS, 2014).

Furthermore, the academy has been investing and understanding how parts of these games can contribute to the improvement of systems, especially in educational environments (DICHEV; DICHEVA, 2017). From these efforts, the concept of gamification emerged, being defined as *the use of elements (or parts) of games outside their original context* (DETERDING *et al.*, 2011; SEABORN; FELS, 2014). This concept has been widely used in the area of education, achieving several positive results (KLOCK *et al.*, 2020). The large-scale use of gamification has attracted the attention of several specialists in the field of education (such as teachers, instructors and developers), besides most of today's applications are intrinsically gamified (MARTÍ-PARREÑO; SEGUÍ-MAS; SEGUÍ-MAS, 2016; SÁNCHEZ-MENA; MARTÍ-PARREÑO, 2016; AN *et al.*, 2020).

However, in order to achieve the desired positive effects, it is necessary for gamification

to follow an appropriate design (ZICHERMANN; CUNNINGHAM, 2011; SEABORN; FELS, 2014; MORA *et al.*, 2017), which needs to consider various characteristics of the user (such as demographic data, behavioural profiles, etc.) (SANTOS; BITTENCOURT; VASSILEVA, 2018). Achieving this design, however, is not a trivial task, especially if we consider an educational context where several domain experts (e.g. teachers and instructors) have a limited and / or restricted agenda (AN *et al.*, 2020). In short, there is an interest, but the lack of resources and knowledge hinder the adoption of gamification by these professionals, which motivate us to explore the following research question:

How can we contribute to the planning of gamification in educational contexts?

Within this context, the objective of the Chapter is to summarise the three research topics of interest to the author in the area of Computing Applied to Education: Gamification in education, gamification design focused on education, and data mining for gamification applied in education. These themes are integrated by the author in order to make the use of gamification effective in educational contexts, increasing its adoption by teachers and, consequently, improving student performance. In each Chapter we focus on exploring an existing research question or gap.

After the concepts defended in this Chapter, the results of research carried out by the author (alongside with his colleagues and collaborators in Brazil and abroad), will be presented and discussed in later Chapters. Thus, this Chapter seeks to highlight the author's contributions in generating knowledge and resources for applying gamification in education, as well as helping teachers and instructors.

1.1 Gamification in Education

The emergence of gamification has several sources, among them, Nelson describes that gamification has existed since the former Union of Soviet Socialist Republics, being studied in depth in the 1980s by the United States (NELSON, 2012). According to the author, the precursor of gamification is the "Funfication" movement that aimed to make the work environment playful and, consequently, increase productivity without increasing expenses (NELSON, 2012).

Other authors have described the emergence of gamification in the mid-2000s, when the term had been coined in a lecture given by Nick Pelling, where he defined it as the use of game elements in other activities (MORA *et al.*, 2017; BUCKLEY *et al.*, 2018). Although the concept is intrinsic to several applications that have emerged since Pelling's lecture, it only gained space and notoriety in mid-2011 , through the research made by Deterding et al. (DETERDING *et al.*, 2011). Since then, the term has been gaining momentum, even being the target of projections by the Gartner Group, which predicted that until 2016 every company would have at least one internal gamified process (GARTNER, 2011). Henceforth, this projection have been achieved before the stipulated period (DICHEVA; DICHEV, 2015; DICHEV; DICHEVA, 2017).

However, when we consider the educational context, it is clear that gamification has been around for longer. According to Smith-Robbins (SMITH-ROBBINS, 2011), the traditional educational system is already a gamified system, since the students accumulate points for their performance, advance several levels, so that, at the end of their journey, they obtain the maximum reward, this being the University Degree. The objective of using gamification in educational contexts is to improve motivation and engagement, which directly impact upon their performance, which may not always be the case in traditional education systems (KAPP, 2012).

Since then, researchers have been mobilised to understand the effects of gamification on student motivation and engagement. According to Darejeh and Salim (DAREJEH; SALIM, 2016), the area of education is one of the most focused, as well as one of the ones with the most mixed results. This means that, despite several studies, there are still no conclusive results regarding the interference of gamification in the teaching and learning process of students (BORGES *et al.*, 2014; SEABORN; FELS, 2014; KLOCK *et al.*, 2020). This occurs due to several factors, among them the planning of gamification (which will be more detailed later in Chapter 2), as well as the ease of understanding and resources for its adoption to be effective when applied by specialists in the field.

Adoption by teachers, according to Marti-Parreño, Sánchez-Mena and De Paula (SÁNCHEZ-MENA; MARTÍ-PARREÑO, 2016; MARTÍ-PARREÑO; SEGUÍ-MAS; SEGUÍ-MAS, 2016), does not occur, due to three main factors: lack of resources, time and knowledge. This happens because the teacher, generally, has an arduous routine (this effect is even more predominant in Brazil, where some teachers experience high to moderate stress due to many factors (FERNANDES; VANDENBERGUE, 2018; da Silva Hanzelmann *et al.*, 2020)). Furthermore, there is no time to study the various properties required for good gamification planning, or to adapt them to their educational contexts. This led us to our first sub-question (SQ1):

How can we summarise knowledge for teachers and other education field experts?

To answer this question, the contributions of the author are aligned with the conduction of systematic secondary studies (TODA; VALLE; ISOTANI, 2018; TODA *et al.*, 2018), to understand which gamification elements might be useful or harmful to the students. In addition, the author contributes with examples and proposals on how gamification can be included in the development of open resource platforms (M. Toda *et al.*, 2017) and the identification of challenges for planning gamification in the educational context (TODA *et al.*, 2017). Finally, the main general contribution of the author is a model that aggregates several elements of games, as well as their synonyms, that can be used in the planning of gamification in educational contexts (TODA *et al.*, 2019b).

1.2 Gamification Design

Gamification design (or planning) is characterised by a series of events that result in a gamified strategy (which is a specific action related to game elements) (TODA *et al.*, 2018a). This design is one of the factors that influence the success of gamification in an educational environment, and skipping this step can cause unwanted effects or even the loss of engagement and motivation (DICHEV; DICHEVA, 2017; TODA; VALLE; ISOTANI, 2018). According to the literature, design can be supported by the use of frameworks (AN *et al.*, 2020).

Frameworks, in the context of this work, are defined as a set of steps and tools aimed at a certain result, in this case a gamified strategy. According to the literature, the number of frameworks for gamification has increased dramatically in recent years (MORA *et al.*, 2017). For Mora et al., several of these frameworks are in the conceptual phase and / or with their use restricted to academia, in addition to covering various areas of knowledge such as education, tourism, health. Among these, there are also generic frameworks, which according to the concept, can be applied in any field. In this work, we can mention two of the most famous generic frameworks (according to the literature), being Six steps to gamification (6D) (WERBACH; HUNTER, 2012) and Octalysis (CHOU, 2012). One problem arises from the use of generic frameworks, which is: they do not address educational characteristics of an environment (MORA *et al.*, 2017), and some present too broad concepts to be analysed and defined by teachers and instructors (e.g. the concept of *Fun*).

In a recent literature review proposed by Mora et al., we can observe 6 frameworks focused on educational domains (MORA *et al.*, 2017). Another review conducted by the author of this thesis encountered 17 uses of frameworks on a national scale (TODA *et al.*, 2018). Finally, a review conducted by Rauschenberger et al identified 10 approaches that were used to gamify learning environments (RAUSCHENBERGER *et al.*, 2019). As can be seen, despite being ”different”, these frameworks have similar steps and characteristics, either by investigating the type of user or by the set of game elements (TODA *et al.*, 2018). However, although these frameworks solve (partially) the problem related to the synthesis of knowledge, the people interested (e.g. teachers) are still responsible for studying each one of these frameworks and generating their gamified strategies to use in their educational contexts, which is still a big problem for the teacher, given their high workload (da Silva Hanzelmann *et al.*, 2020). Based on this premise, we have explored in this section another sub-question (SQ2):

How can we systematise the knowledge presented in the literature, to extract and understand what is necessary to create and implement appropriate gamification strategies in educational contexts?

From the studies of the different frameworks, the author of this thesis also proposed the creation of a new conceptual framework (TODA *et al.*, 2016), which was evaluated by experts and of which some instances were applied in different educational contexts (TODA *et al.*, 2018a;

TODA *et al.*, 2019d; TODA *et al.*, 2019a). One of the main essential differences of this framework is that the domain specialist has the assistance of a game designer, or gamification designer, to help with the selection of game elements for their specific context, reducing significantly the workload of the domain expert. During this thesis, this framework was gradually built, and the results of each research stage was published in our various studies. These studies range from the initial concept (TODA; ISOTANI, 2016) to the application of early versions in different courses through different research collaborations as: biochemistry (TODA *et al.*, 2016), introduction to programming (TODA *et al.*, 2018b), introduction to business (OLIVEIRA *et al.*, 2020), and others. In this Chapter we also present how our proposed taxonomy for gamification elements can be used to analyse and design educational learning systems (TODA *et al.*, 2019d; TODA *et al.*, 2019a), as well as how we integrated it with our conceptual framework and other characteristics (e.g. culture).

1.3 Data-Driven Gamification Design

As studies in the field of gamification progressed, researchers identified several discrepancies (e.g. positive and negative impacts on motivation / amotivation, students' performance, etc.) between what was stated in the literature and the results of experiments (SEABORN; FELS, 2014; KOIVISTO; HAMARI, 2019). Furthermore, new research areas have been trying to focus on using data to redefine existing concepts in gamification, specially to assist in the decision-making process of the design (MEDER; PLUMBAUM; ALBAYRAK, 2017). Through these efforts, the Data-driven gamification design area (DDGD) emerged (MEDER; PLUMBAUM; ALBAYRAK, 2017).

DDGD consists of using machine learning algorithms in data sets to discover patterns and create prediction models (MEDER; PLUMBAUM; ALBAYRAK, 2017). Machine learning is an area defined as the study that allows computers the ability to learn, without being explicitly programmed, characterised in two ways: unsupervised and supervised (ALPAYDIN, 2020). Unsupervised learning encompasses data mining algorithms, whose objective is to find patterns that assist in decision making and, subsequently, can be used as models in supervised learning algorithms (GHAHRAMANI, 2003). Supervised learning, on the other hand, considers that we already know the result of an action, given an initial data set (ALPAYDIN, 2020).

In the scope of this thesis, we aimed to explore to which extent unsupervised learning algorithms can aid in the design process, since the results that are present in the gamification literature do not allow us to create accurate models (SEABORN; FELS, 2014). This occurs due the discrepant effects that can be found in studies in the field, where the same set of elements can positively or negatively impact a group of students. Besides, unsupervised learning can be used to assist in the decision-making process (AGRAWAL; IMIELIŃSKI; SWAMI, 1993; GHAHRAMANI, 2003) which can help us with the following sub-question (SQ3):

How can we provide resources to the domain expert, to support the decision-making process of gamification design in educational contexts?.

In the context of this research direction, the thesis author proposed the use of Association Rule Mining (ARM) and clustering algorithms to find patterns within given datasets, which can be used in the decision-making process of teachers and instructors. ARM was chosen due to its prior use in decision-making process in other areas (e.g. market basket analysis (AGRAWAL; IMIELIŃSKI; SWAMI, 1993)), where we can explore the relations between elements and users' characteristics (e.g. demographics). According to a recent review, cluster-analysis can also be an effective way for the decision-making process (CARUSO *et al.*, 2017).

Recent studies have already demonstrated the use of clustering in conjunction with gamification, in order to identify student profiles and their characteristics as programmers (PEREIRA *et al.*, 2020). The literature has also presented studies trying to group students based on their behaviours obtained through medals (badges) (MCDANIEL; FANFARELLI, 2016), and they have also analysed player profiles based on groupings (RAJANEN; RAJANEN, 2017). Concerning the use of ARM, only one study was reported, using association rules to relate student demographic data and their performance in classes, through the use of gamified systems (AYUB *et al.*, 2019). Another recent work, developed by Palomino et al (PALOMINO *et al.*, 2019) also used rules of association to identify sets of elements that would be related to the elements of narrative and storytelling, using the method developed in our study that will be presented in later Chapter 4.

As noted, there is still a shortage in the literature regarding the use of machine learning in data sets involving gamification. In addition, only one of the related studies identified has a focus related to gamification design, directed at a set of specific elements. Furthermore, at this stage of the work, we contribute to the field of gamification and education through a method to collect, extract and analyse data, in order to produce gamified strategies based on real users' data (TODA *et al.*, 2019c), as well as evaluating those strategies based on users' feedback (TODA *et al.*, 2019). We also provide here some insights that were collected based on users' intention to use gamification, that were analysed and inferred based on a data-driven process (TODA *et al.*, 2020).

1.4 Final Remarks

This Chapter aimed to present initial concepts related to the topics covered in this collection. The general motivation of the work was presented, as well as the problem to be solved in each of the three fields described, alongside the sub-questions of each field. The following sections will address the thesis' author's contributions to each of these fields: Chapter 2 addresses the theoretical contributions to the field of gamification in education; Chapter 3 deals with the conceptual framework and its instances; Chapter 4 addresses the method developed and the

results obtained from the use of machine learning algorithms; Chapter 5 presents the conclusions obtained from the realisation of the work on this thesis. Finally, the annexes contain the original publications published during the five years of development of this doctoral work.

CHAPTER

2

GAMIFICATION APPLIED TO EDUCATION

This chapter aims at describing the author's contributions to the theoretical field of gamification applied to education. These contributions can be seen through systematic mappings and redefinition of pre-existing concepts in the educational context. Additionally, this thesis also present models as theoretical contribution, that can be used to aid in the gamification design and consider different aspects (such as culture) which are often neglected by prior research. Each one of the works presented in this Chapter present a research question or gap that, when solved, can support us to answer one of our main research questions in this work. We will be referring to these sub-questions as Sub-Research Question (SRQ) or Sub-Research Gap (SRG).

2.1 The dark side of gamification: An overview of negative effects of gamification in education

Gamification in education has been used mainly to improve motivation, engagement and teaching practices (KAPP, 2012; DICHEV; DICHEVA, 2017). However, most of the studies present inconclusive reports towards the effectiveness of gamification, Seaborn and Fels even discuss the discrepancy between theory and practice, where most studies attest that gamification improve motivation while other studies says the opposite (SEABORN; FELS, 2014).

Based on this premise, we aimed at investigating which negative effects can occur when applying gamification in educational contexts, by conducting a systematic mapping (TODA; VALLE; ISOTANI, 2018). This mapping was conducted following the guidelines proposed by Kitchenham (KITCHENHAM *et al.*, 2009).Details on the protocol can be found in Annex A.

This work aimed at answering two research questions: **SRQa - What are the negative outcomes related to gamification in Education?**; and **SRQb - How is the gamified design related to these outcomes?**. SRQa focuses at identifying and classifying these negative effects while question SRQb aims at identifying the design (e.g. the gamification elements) associated

with these effects.

Through our analysis (Annex A), we collected a total of 1328 works from 2011/1 until 2016/2, from eight different databases. After the initial screening, where we analysed titles, abstracts and keywords, and applied the inclusion/exclusion criteria, we ended with a pool of 17 papers. From those papers we identified four types of negative effects, answering our SRQa:

- **Indifference (6 studies)**: Occurs when gamification has no effect at all.
- **Loss of Performance (12 studies)**: Occurs when gamification hinders the performance of the students.
- **Undesired Behaviour (9 studies)**: Occurs when gamification provokes different behaviours from the ones that were planned initially.
- **Declining Effects (5 studies)**: Occurs when gamification decreases the motivation and engagement over time, during its application.

In addition, we identified the design that was associated with these behaviours, and found out that the use of Points, Badges and Leaderboards (or Point, Acknowledgement and Competition) were heavily used when these effects occurred. An overview of the study can be seen in Figure 1.

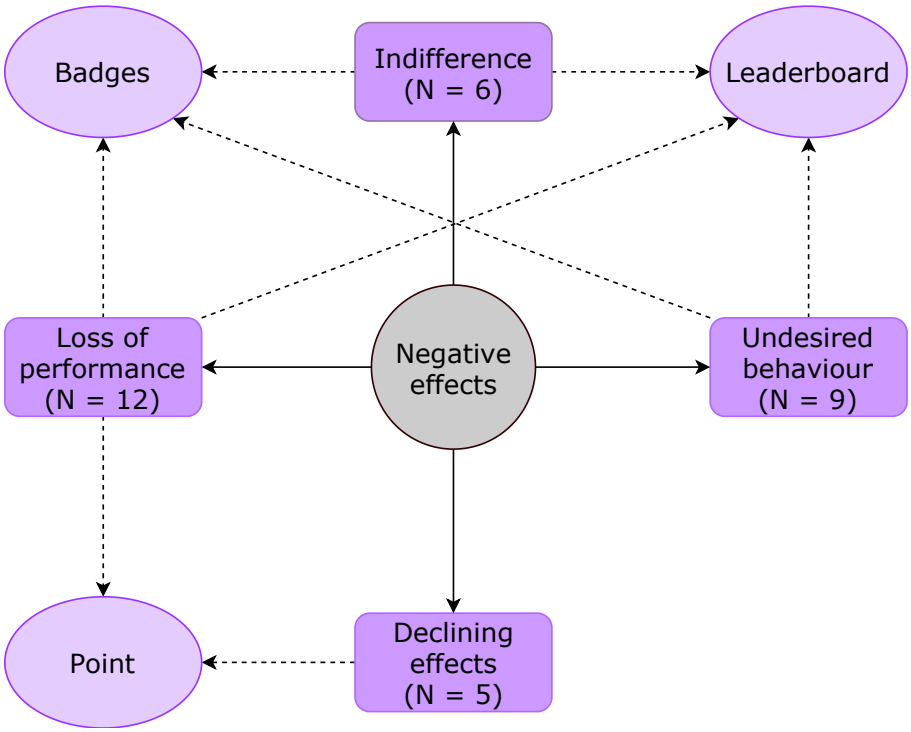

Figure 1 – Summary of results in (TODA; VALLE; ISOTANI, 2018)

Considering this study, our contributions can be summarised as: (i) being the first study to identify and map negative outcomes towards gamification in educational contexts; (ii) to

analyse the design that might lead to these outcomes, based on evidence, finding out that Point, Acknowledgement and Competition can lead to those effects, when applied inappropriately.

2.2 Challenges for planning gamification in educational context

In this study, we focused on identifying the main challenges for gamification planning in education. To map these challenges, we conducted a tertiary study (which is a literature review of literature reviews) following a systematic mapping protocol (TODA *et al.*, 2017). The SRQ that guided this study was: SRQc - **What are the major challenges related to gamification planning and deployment in educational contexts?**

After some conceptual definitions (Annex B), we choose the following databases: IEEE Xplore, ACM Digital Library, Scopus, Engineering Village, Web of Science e ScienceDirect. In these databases, we used the following terms and adapted to each search string: ”Gamification”, ”Meta-analysis”, ”Systematic mapping”, ”Systematic Review” and ”Literature review”.

Our analysis returned a total of 615 studies, where only 30 were pre-selected to be analysed, and only 11 were chosen for the final analysis (after the filtering process, detailed in Annex B). In our final analysis, we found seven challenges that hindered gamification planning in education:

- **Lack of empirical evidences**: studies do not provide sufficient empirical data on the positive effects of gamification;
- **Lack of specific methods**: studies do not used well-defined metrics, nor instruments to verify what they want (e.g. motivation);
- **Customisation**: when the planned gamification is not tied to users' characteristics and how to extract or analyse these same characteristics (e.g. user profiles);
- **Undesired behaviours**: when the planned gamification aimed at a certain behaviour, but another one occurred (e.g., planning to increase students' motivation but in practice it decreased their motivation);
- **Lack of proper definitions**: lack of proper definitions and terms to be used as a consensus (e.g. elements with same concepts but different names across many studies);
- lack of computational support: lack of tools to support the design process.

We also identified in this study how some of these challenges are related. According to our analysis, the lack of empirical evidence is tied to the lack of specific methods and customisation,

while customisation influences the undesired behaviours (which occurs when gamification is not tied to user characteristics). An overview of our study can be seen in Figure 2.

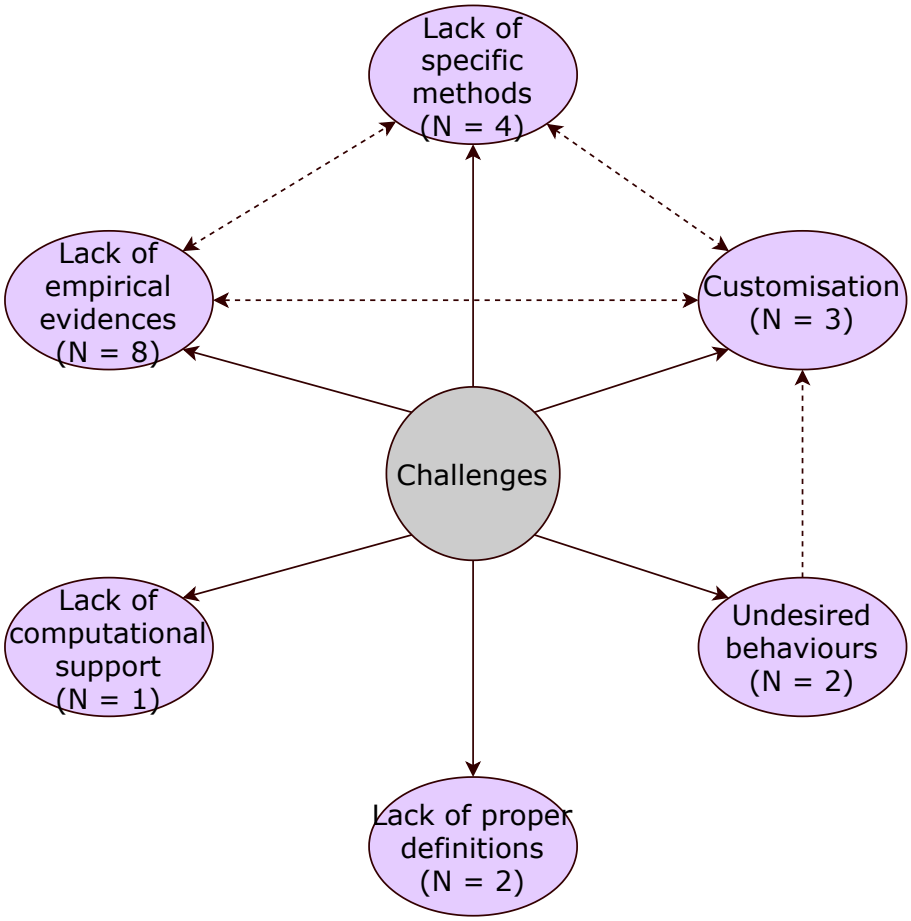

Figure 2 – Summary of (TODA *et al.*, 2017)

Overall, our main contribution is the summary of the challenges that need to be addressed to design gamification. Most of these challenges are aligned with theoretical studies, as in Seaborn and Fels (SEABORN; FELS, 2014) and Koivisto and Hamari (KOIVISTO; HAMARI, 2019). In this PhD. thesis, we managed to tackle some of these challenges, such as lack of specific methods (by designing our framework focused on the educator, which will be presented further (TODA *et al.*, 2018a)), lack of proper definitions (by providing a taxonomy that can be used as a dictionary of gamification elements for educational contexts (TODA *et al.*, 2019b)) and lack of computation support (by providing resources to be used by teachers and for teachers, to design their gamification properly (TODA *et al.*, 2019c)).

2.3 Designing Gamification for educational contexts: A national systematic mapping

In this study, we aimed at identifying and analysing gamification frameworks used at a national scale (Brazil) through a systematic mapping (TODA *et al.*, 2018). The research

questions used to drive this study were: **SRQd - Do these frameworks provide computational resources to aid in the design phase?**; SRQe - **How do these frameworks personalise the gamification?**; and **SRQf) How many game elements are used within these frameworks?**

Based on these questions, we next focused on finding studies that were conducted in Brazilian universities, in the CEIE portal, Scopus and New Technologies in Education journal[1] (all these databases are very relevant in the context of computers in education). We used an adapted research string that contained the following terms ”approach”, ”strategy”, ”framework”, ”method”, ”process”, ”methodology”, ”planning”, ”technique” and ”gamification”. Initially, we found 61 studies, out of which only 18 passed through our filtering process (more details in Annex C). As for our research questions and contributions:

SRQd We did not find any computational resources to aid in the design phase;

SRQe Six studies considered player profiles, while two considered demographics and one considered roles for personalisation;

SRQf 11 studies considered or defined game elements, and these elements were presented in a non- identifiable form (eight studies) while three defined classifications for these elements.

A summary of our findings can be seen in Figure 3. These findings were important to guide and motivate us to design tools to aid in the design process that would consider other kinds of personalisation as well as the number of gamification elements (e.g., our taxonomy for gamification elements in educational contexts (TODA *et al.*, 2019b)).

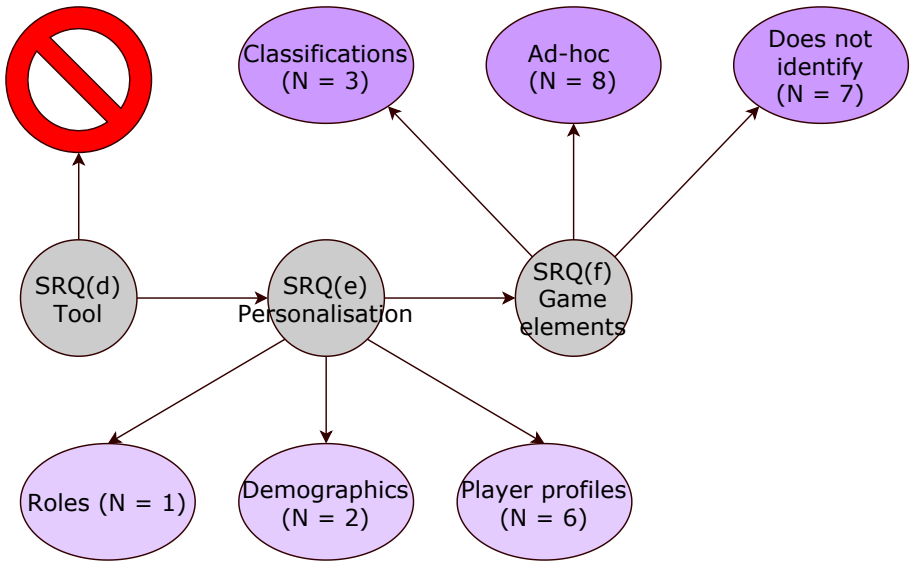

Figure 3 – Summary of (TODA *et al.*, 2018)

[1] RENOTE

2.4 A taxonomy of game elements for gamification in educational contexts: Proposal and evaluation

An issue that is reported by gamification studies is concerned with the game elements that are used (TODA *et al.*, 2017). Most of the literature refers to different game elements that, in definition, have the same concept, which can hinder the adoption of gamification by educators and other domain experts in this field (TODA *et al.*, 2019b).

Based on this premise, we aimed at designing and proposing a taxonomy that could include all (most of) the game elements that are present in the gamification literature. Based on previous literature reviews, we analysed gamification frameworks and defined 19 game elements alongside their possible synonyms (SRGa).

Following, we conducted an evaluation with gamification and education experts (N = 19), based on the concepts of comprehensibility, descriptions, examples, and coverage of these game elements (these concepts are explained and described in Annex D). These experts also evaluated the game elements, by ranking from the most relevant to least relevant and could add elements that were not within our initial classification.

On our initial analysis, all the concepts that were investigated achieved a high confidence of answers (Cronbach's $\alpha > 0.8$), and none of the 19 initial game elements were considered irrelevant. Based on the suggestions of some experts, we also included the elements of Narrative and Storytelling. Then, we proposed the taxonomy of gamification elements composed of 21 elements, alongside their synonyms.

Finally, based on a semantic and interaction analysis (e.g., the description of the game elements and examples of their use in the literature) we proposed an initial classification on which psychological aspects these elements might influence as motivation and engagement. Based on the experts' evaluation, most of our concepts achieved more than 3.8 average, which can be considered a positive agreement. A summary of the study can be seen in Figure 4.

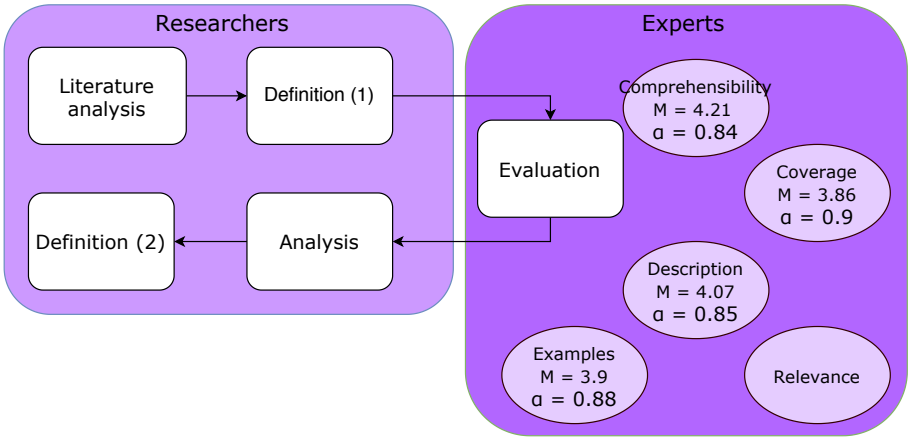

Figure 4 – Summary of the study in (TODA *et al.*, 2019b)

The main contribution of this part of the work was providing a taxonomy that can be used to represent the majority of game elements presented in the literature (TODA *et al.*, 2019b). Another possible contribution of this work is the evaluation by experts in the field. Through this evaluation, we could observe that most of the elements were accepted as they were presented, alongside their examples and synonyms, and the most relevant elements were Objectives, Level and Progression, which might provide preliminary insights on how to use these elements. The complete Taxonomy can be seen in Table 1.

Table 1 – Taxonomy of gamification elements, as seen on (TODA *et al.*, 2019b)

Concept	**Description**	**Dimension**
Acknowledgement	Type of feedback that praises the players' specific actions. Some examples and synonyms are badges, medals, trophies.	Performance
Chance	Randomness and probability properties that increase or decrease the odds of certain events; examples/synonyms: randomness, luck, fortune.	Ecological
Competition	When two or more players compete against each other towards a common goal; examples/synonyms: Player vs Player, scoreboards, conflict.	Social
Cooperation	When two or more players collaborate to achieve a common goal; examples/synonyms: teamwork, co-op missions.	Social
Economy	Transactions within the game, monetising game values and other elements; examples/synonyms: markets, transaction, exchange.	Ecological
Imposed Choice	Decisions that the player is obliged to make in order to advance the game; examples/synonyms: judgements, forced choices (different from Narrative).	Ecological
Level	Hierarchical game layers, providing a gradual way for players to obtain new advantages upon advancing; examples/synonyms: character levels, skill level.	Performance
Narrative	Order of events happening in a game; i.e., choices influenced by player actions; examples/synonyms: strategies the player uses to go through a level (stealth or action), also the good/bad actions influencing the ending, karma system (different from Imposed Choice).	Fiction
Novelty	New, updated information presented to the player continuously; examples/synonyms: changes, surprises, updates.	Personal
Objectives	Guide the players' actions. Quantifiable or spatial, from short- to long-term; examples/synonyms are missions, quests, milestones.	Personal
Point	Unit used to measure users' performance; examples/synonyms: scores, number of kills, experience points.	Performance
Progression	This allows players to locate themselves (and their progress) within a game; examples/synonyms: progress bars, maps, steps.	Performance
Puzzles	Challenges within the game that should make a player think examples/synonyms: actual puzzles, cognitive tasks, mysteries.	Personal
Rarity	Limited resources and collectables; examples/synonyms: limited items, rarity, collection.	Ecological
Renovation	When players can redo/restart an action; examples/synonyms are extra life, boosts, renewal.	Personal
Reputation	Player titles to accumulate in-game; examples/synonyms: titles, status, classification.	Social
Sensation	Use of players' senses to create new experiences; examples/synonyms: visual stimulation, sound stimulation.	Personal
Social Pressure	Pressure through social interactions with another player (s) (playable and non-playable); examples/synonyms: peer pressure, guilds.	Social
Stats	Visible information for the player, about their in-game outcomes; examples/synonyms: results, health bar, magic bar, HUD, indicators, data from the game presented to the user.	Personal
Storytelling	The way the story of the game is told (as a script) within the game, via text, voice, or sensorial resources; examples/synonyms: stories told through animated scenes, audio queues or in-game text queues.	Fiction
Time Pressure	Pressure through time in-game; examples/synonyms: countdowns, clock, timer.	Ecological

2.5 GamiCSM: Relating education, culture and gamification - a link between worlds

In this work, we explored how we can integrate culture in gamification for educational environments (TODA *et al.*, 2020). It is known that gamification design considers many aspects based on users' and context. However, most of the existing approaches often ignores culture, which is also an important aspect, especially for educational purposes (ALMARSHEDI; WANICK; WILLS, 2016; KLOCK *et al.*, 2020).

Based on this premise, we aimed at (SRGb) designing a model that could relate the cultural aspects from Hofstede's Cultural Dimensions (HOFSTEDE, 2011) and gamification elements presented in our Taxonomy of Gamification Elements for Educational Environments (TGEEE) (TODA *et al.*, 2019b).

To design this model, we used an ontological approach, since ontologies are used to identify relations between abstract concepts (ISOTANI; BITTENCOURT, 2015). This was followed by a survey study, where we contacted experts from the fields of gamification, culture, and education, to evaluate our model.

Overall, our model had mixed reviews from the experts, some suggested the reallocation of some of the gamification elements, while other suggestions were to remove some relations from our initial proposition (details in the paper, in Annex E). Based on the evaluations that were provided, we could relate 5 dimensional cultures and 18 gamification elements in our initial model (Figure 5).

Our main contribution in this part of the work is the *first model to relate culture and gamification for educational environments, that can be used to adapt gamification* based on those dimensional cultures, as well as to provide guidelines for teachers that want to implement positive attitudes through culture (e.g. collectivism social elements).

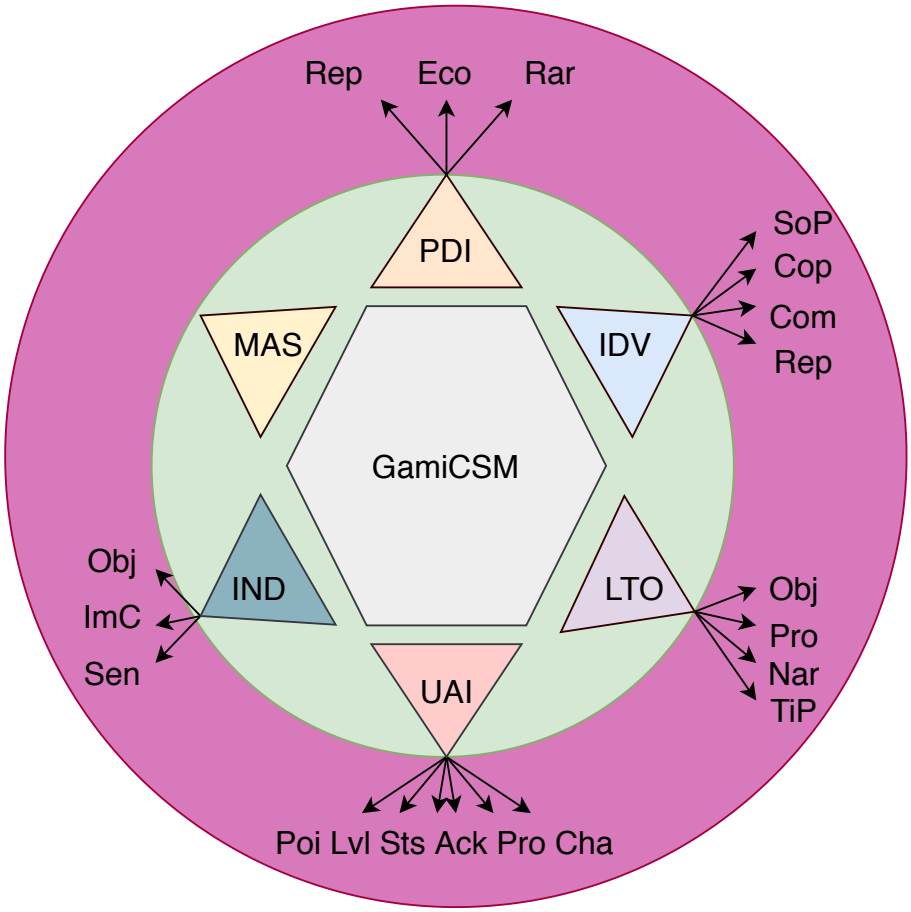

Figure 5 – Model proposed in (TODA *et al.*, 2020)

2.6 Final Remarks on this Chapter

This Chapter presented the contributions made by the author to the theoretical field of gamification in education, through answering multiple research questions and trying to address some research gaps. In this sense, we provided contributions by mapping the negative outcomes and analysed the design of these effects, which may help future decision-making processes in educational environments. Next, we presented challenges and research directions on the design of gamification in educational contexts. We also presented a list of gamified approaches (on a national scale) that were used in the past years. Then, we proposed and evaluated a taxonomy of gamification elements that can be used within educational environments, which we further expanded by providing different theoretical dimensions that can be used to analyse existing educational applications. In addition, we also provided the first model to relate culture and gamification in educational context, for design purposes, that can be used as an alternative of the existent ways of gamifying educational environments. The works presented in this Chapter also guided some of our research directions and help us to find a solution to the first sub-question ”How can we summarise knowledge for teachers and other education field experts?” alongside other solutions presented throughout this thesis. To summarise the knowledge, we first need to understand (a) what has been done; and (b) what consequences this might bring to the students.

Then, we can start to summarise the game elements presented in the literature through our taxonomy, as well as present how these elements can be related to other aspects, such as culture. The full contributions in this field can be found in the Annex.

CHAPTER

3

GAMIFICATION DESIGN

This Chapter aims at describing the contributions of the student to the field of Gamification Planning, focusing on the design, development and user cases of the conceptual framework that is one of the main contributions of this project, which also provides another answer to our main RQ "How can we contribute to the planning of gamification in educational contexts?"

3.1 A process for generating gamified designs for teaching

In this short study (TODA; ISOTANI, 2016), we reported the initial concept of this PhD project, by designing a process to gamify learning contexts. This process uses the teachers' planning as an input, and after four distinct phases, it returns a gamified design. These phases can be described as:

- Definition of content: The teachers' planning content is analysed;
- Definition of the gamification elements: The game elements are chosen and applied to the content that was defined in the first step;
- Implementation: We define how the tasks will be implemented in the educational environment;
- Validation: We evaluate the process through the use of validated instruments by measuring students and teachers' feedback.

In this initial version (Annex F), we designed two groups of game elements called Feedback and Property elements. Feedback elements are extrinsic rewards that could be used as a way to provide feedback on the students' interactions, composed of 6 elements. As for the

Property elements, these are defined as characteristics (usually intrinsic) to a task, composed of 12 elements. This initial set of game elements was used as a base (alongside literature reviews) for us to define the TGEEE (TODA *et al.*, 2019b). Since this is an initial version of what was intended to be a major approach on how to gamify learning environments, we did not covered any SRQ or SRG.

3.2 A gamification process in higher education: Perspectives from a Biochemistry module

In this following study (TODA *et al.*, 2016), we demonstrate an instance of the aforementioned process (TODA; ISOTANI, 2016) in a Biochemistry course. We aimed to understand how the students' motivation was affected by the gamification design and the instructors' thoughts (SRGc).

Based on the aforementioned (TODA; ISOTANI, 2016) steps, the instructor generated and implemented a list of gamified strategies based on an Economy approach, where the students would gain Points based on specific actions and behaviours. These Points could be exchanged by advantages in-class, e.g. ask for a hint during a test.

After experiencing the gamified strategies for a whole semester, the students were asked to answer the Intrinsic Motivation Inventory (IMI), based on the Self-Determination Theory (DECI; RYAN, 1985), using the following dimensions: Interest and Enjoyment, Perceived Competence, Pressure and Tension, and Perceived Choice. The questionnaire was presented through a printed version using a Likert scale (LIKERT, 1932) from 1 to 7, where 1 meant "Not true" while 7 meant "Totally true". More details on Annex G.

The analysis on the students' motivation presented overall positive results. In the Interest and Enjoyment dimension, students stated their interest and enjoyment while doing the activities. As for the Perceived Competence, students did not feel like gamification had an impact during the course but felt confident after the semester was over. Considering the Pressure and Tension, most of the students where indifferent, most tending to not feeling pressured during the activities. Finally, for the Perceived Choice, most students felt they were doing the activities because they wanted to, instead of being obliged. These analyses differ when we analyse from the perspective of gender (see explored and detailed analysis in the Annex G). Overall, our main contribution in this study was to present an instance of the process created in (TODA; ISOTANI, 2016). In this study, we also cover SRGc, by applying gamification in a context different from usual (Biochemistry course) when, at the time this study was published, the majority of contexts where gamification was applied consisted in Computer Science and Mathematics (DAREJEH; SALIM, 2016).

3.3 An approach for planning gamification concepts with social network features within educational contexts

In this study, we aimed at formalising the previous process into a framework, containing a series of procedural steps to design a *gamified strategy* to be used in learning domains (TODA *et al.*, 2018a). In this approach, we aimed at connecting gamification design with social network elements, since recent studies on the field at the time demonstrated that gamification with social features seems to be more effective than individual one-size-fits-all designs (DE-MARCOS; GARCIA-LOPEZ; GARCIA-CABOT, 2015).

In addition, the main objective of this work was to provide guidelines for teachers and instructors on how to gamify learning environments (SRGd). This gap is presented in the literature review provided by Mora et al (MORA *et al.*, 2015; MORA *et al.*, 2017) where they presented (a) few frameworks to support educational environments, (b) no frameworks focusing on the stakeholders that were going to plan and implement the gamification, and (c) did not presented a validation nor an instance of its application.

Based on this premise, we designed the GAMIFY-SN[1]. This approach consists in 4 steps, that are divided between two roles: Teachers/Instructors and Game/Gamification designer. These steps are defined, based on the previous work (TODA *et al.*, 2016): (a) Definition of the content; (b) Definition of the game elements; (c) Deployment; and (d) Evaluation. Based on feedback provided in the previous study, we defined that steps (a) and (c) where suited to be conducted by teachers and instructors, while steps (b) and (d) would be suited for the game/gamification designer. A summary of the approach can be seen in Figure 6.

In this iteration of the approach, the teacher/instructor is responsible to provide the instructional resources (IR, as seen on Figure 6). Then, they choose which social network features they would like to use, as well as mapping their activities. This whole step generates a representation which can be achieved through a conceptual map.

Following, the next step is conducted by the game/gamification designer, where they will analyse the representation of the previous step, containing the activities and features the instructor would like to use, and will define the gamified tasks. These tasks are the junction between gamification elements and the learning activities. By the end of this step, the designer produces the gamified tasks and their evaluation, which will be given to the instructor.

In the next step, the instructor must apply an onboarding moment where they will explain the rules of the gamified tasks to the students. After a mutual agreement between the instructor and the students about the rules, the application phase starts, where the instructor must take notes and observe the behaviours of the students. Finally, the designer must apply the evaluation and analyse its results. It is worth mentioning that the evaluation can be carried out by the

[1] SN for Social Network

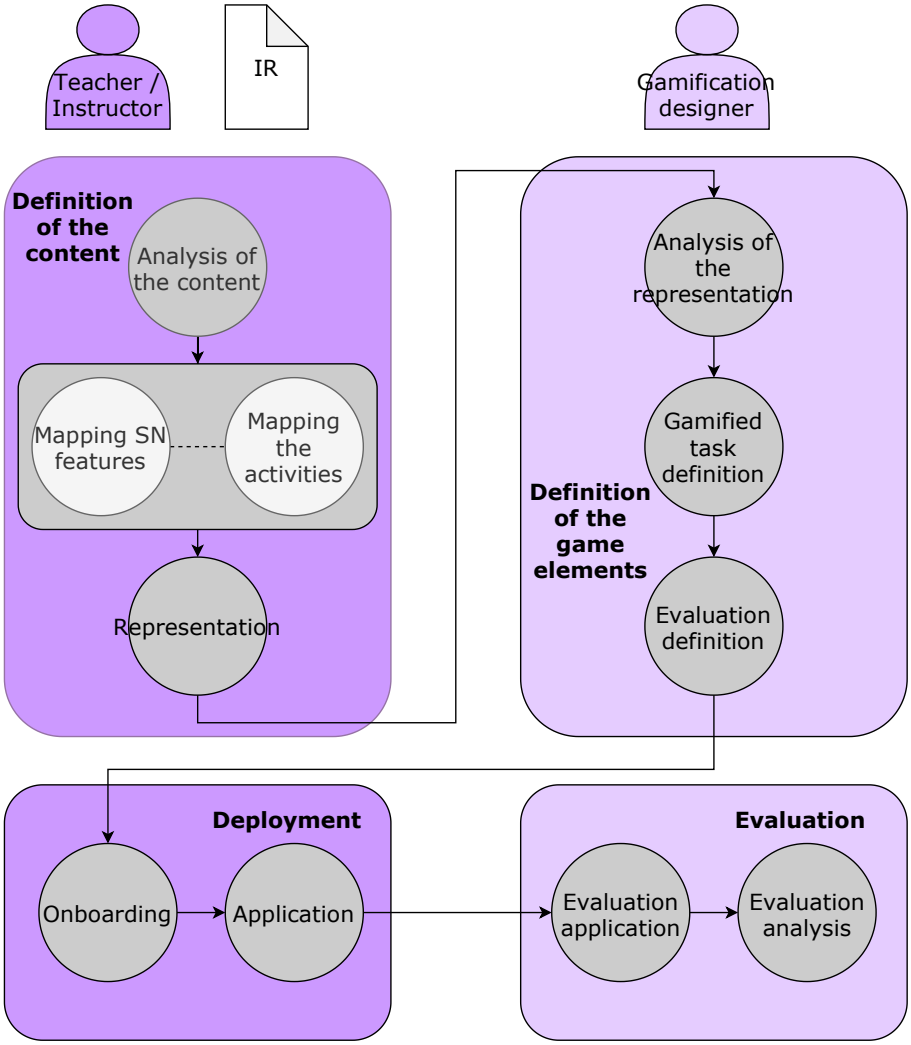

Figure 6 – Summary of Gamify-SN proposed in (TODA *et al.*, 2018a)

teacher/instructor, advised by the designer of the gamified strategy. More details on this approach can be seen on Annex H.

In summary, our main contribution in this work is to provide the first approach focused on the teacher/instructor in education domain. This approach was also evaluated by four experts in the field of education and gamification, to ensure it contained essential aspects for teachers and instructors.

3.4 Analysing gamification elements in educational environments using an existing Gamification taxonomy

An extension of the previous work presented in (TODA *et al.*, 2019b), this work focused on giving more details on the taxonomy that was created, and proposing its use to analyse gamified environments (TODA *et al.*, 2019a). In this sense, as an extension, this work aimed at exploring the following *SRQg*: *How can we use the proposed taxonomy to analyse and evaluate*

gamified educational environments?. Based on our initial proposal, we defined dimensions to group those elements: Performance, Ecological, Social, Fiction and Personal. Each one of these dimensions represents an interaction between the user and the system (Figure 7).

Figure 7 – Taxonomy of gamification elements as seen in (TODA *et al.*, 2019a)

In this new version, the Performance dimension is the interaction ”interface” (action-response) between the system and the user. The elements presented in this dimension are used as general feedback provided by the environment to the users’ actions, also acting as a bridge between the other dimensions.

The Ecological elements are related to the system itself, these elements are properties of the system. This dimension can also be related to Operational rules in game design theories, e.g. rules that describe how the game is played, in this case, the gamified system / environment.

Following, the Social dimension elements are tied to the interactions between players. These interactions can then be supported by Performance elements, such as Points and Levels. Social elements are also related to Implicit / Behavioural rules, which the designer does not have control and must be predicted during the design phase. Specially since social elements (e.g., leaderboards) are associated with most of the negative effects and may lead to many undesired behaviours.

As for the Personal dimension, it is tied to the user of the gamified environment / system. These elements are used to guide these users and provide a personal feedback of the interactions within the system, as well as ways to customise the environment.

Finally, the Fictional elements, Narrative and Storytelling, are contextual elements used to provide direction. While the Narrative is tied to the users' interactions, strategies and choices within the system (as the concept suggests), the Storytelling is tied to the environment to provide context, e.g. a space odyssey thematic.

These groups were provided to help the designer / domain expert to identify key aspects of their environment. In the paper (Annex I) we also propose a way to use these elements to analyse existing gamified environments, so designers can have a (subjective) model of comparison and opt for the elements and dimensions they think are worth. All the elements, alongside their dimensions can be seen on Table 1.

3.5 How to Gamify Learning Systems? An Experience Report using the Design Sprint method and a Taxonomy for gamification elements in education

This study is another extension from (TODA *et al.*, 2019b; TODA *et al.*, 2019a) where we explain how this taxonomy can be used with Design Sprint Method to design gamified educational systems (TODA *et al.*, 2019d). In this sense, this study extended the previous work by focusing on the following *SRQh: How can we gamify learning environments using the Design Sprint method and existing game elements?*

Using the Design Sprint Method, we can provide a proof-of-concept (through a practical model that can prove the theories established by the research). This method is divided in 5 steps, each one representing a day in the overall cycle (more details in Annex J). In our case, this method was used to validate our taxonomy by integrating it within an existing educational system.

In this line of research, we adapted the Design Sprint Method, by defining the following steps: (a) definition of a general gamification design architecture (days 1 and 2); (b) implementation of the elements according to the taxonomy (day 3); (c) gamification design proposal (days 3

and 4); and (d) gamification design instantiation (day 5).

Step (a) consists in organising the gamification elements and defining which ones should appear in which pages of the system, this is done through a brainstorm session. For step (b), we defined the internal relations between the gamification elements and the activities within the system (e.g. when the student finishes a task, which element should be used as a reward to the student), these relations were based on previous research (TODA *et al.*, 2019c).

In step (c), we formalise the gamified strategies produced in the previous steps where the gamified strategy is a task tied to a gamification element e.g., login in the system (task) and receiving a badge (gamification element). Finally, after having all the gamified strategies, we can start step (d) where we implement these tasks within the system. In the paper (TODA *et al.*, 2018a), we give details on how each step is conducted and which artifacts are produced. Then, we demonstrate how the learning system will behave, using our taxonomy elements.

This study is important to provide an alternative way to gamify educational systems, in addition to our approach proposed in (TODA *et al.*, 2018a). This recent approach is more focused in the design and development of systems instead of non-virtual gamification environments. In addition, we also demonstrate how our taxonomy can be applied to a generic design method, and discuss how it can be easily applied to other existing approaches as a way to support the gamification design process.

3.6 Final Remarks on this Chapter

This Chapter presented contributions made by the author to the design of gamification in education, through answering different SRQs and addressing some SRGs found in the literature. In this sense, we provide a conceptual framework to aid teachers and instructors to design gamified strategies with the aid of a game/gamification designer. We also presented how we can use our existing taxonomy to analyse and design gamified strategies for e-learning systems. Through this Chapter, we provided more ways to answer our second sub-question ”How can we systematise the knowledge presented in the literature, to create and implement gamification strategies in educational contexts?” while providing some insights on how to answer our third sub-question ”How can we provide resources to the domain expert, to support the decision-making process of gamification design in educational contexts?”. By presenting a conceptual framework, we tackle both RQs 1 and 2, since this framework also helps to summarise the knowledge, and also provides a way to use it in a systematic manner. We also presented a systematic view on how to use our taxonomy with other existing methods, and other uses of the same taxonomy (analysis). This way, instructors have support to design and analyse their gamified strategies within lessons or systems. The contributions presented in this Chapter can be found in the Annex.

CHAPTER

4

DATA-DRIVEN GAMIFICATION DESIGN

This section aims to describe the authors' contributions to the field of Data-driven Gamification design. In this chapter, we focus on presenting works that can help us answer our third sub-question: "How can we provide resources to the domain expert, to support the decision-making process of gamification design in educational contexts?". Which consequently contributes to answer our main RQ.

4.1 Planning Gamification Strategies based on User Characteristics and DM: A Gender-based Case Study

In this work, we aimed to investigate how gender influences in the preferences for gamified designs (TODA *et al.*, 2019c). We focused in answering the following *SRQi: How can gender differences in preferences about gamification elements be used to support gamification design?*

To conduct this study, we designed a large questionnaire (N = 808 raw answers) where students stated their preferences for gamification elements (N = 19 gamification elements, based on previous works). Following, we used unsupervised algorithm Association Rule Mining (ARM) to identify the relations between the users' genders and their preferences for gamification elements. Then, we analysed the rules that were found and defined a set of recommendations that can be used in gamified designs.

After the filtering process of the raw answers (more details in Annex K), we obtained 733 valid answers. Considering the students' genders, our sample was distributed as 569 male students and 164 female students. Using Mann-Whitney test, we verified that many of the game elements had a significant difference ($p < 0.5$) between genders, as male respondents were more likely to prefer Competition, Cooperation, Social Pressure, Scarcity, and Classification while female respondents would prefer Renovation, Puzzles, and Sensation.

As for the ARM results, we found 25 relevant[1] rules. In summary, some elements were preferred by both genders when tied together as *Progression, Acknowledgement, Data and Objectives*. We also could identify that males would prefer to use more of social interactions, with strong confidence rules pairing gamification elements of Progression and Choice. As for the females, we identified that user experience and rewards are more preferable, with association rules indicating a strong confidence for the need of Acknowledgement and Progression. The summary of our study can be seen in Figure 8.

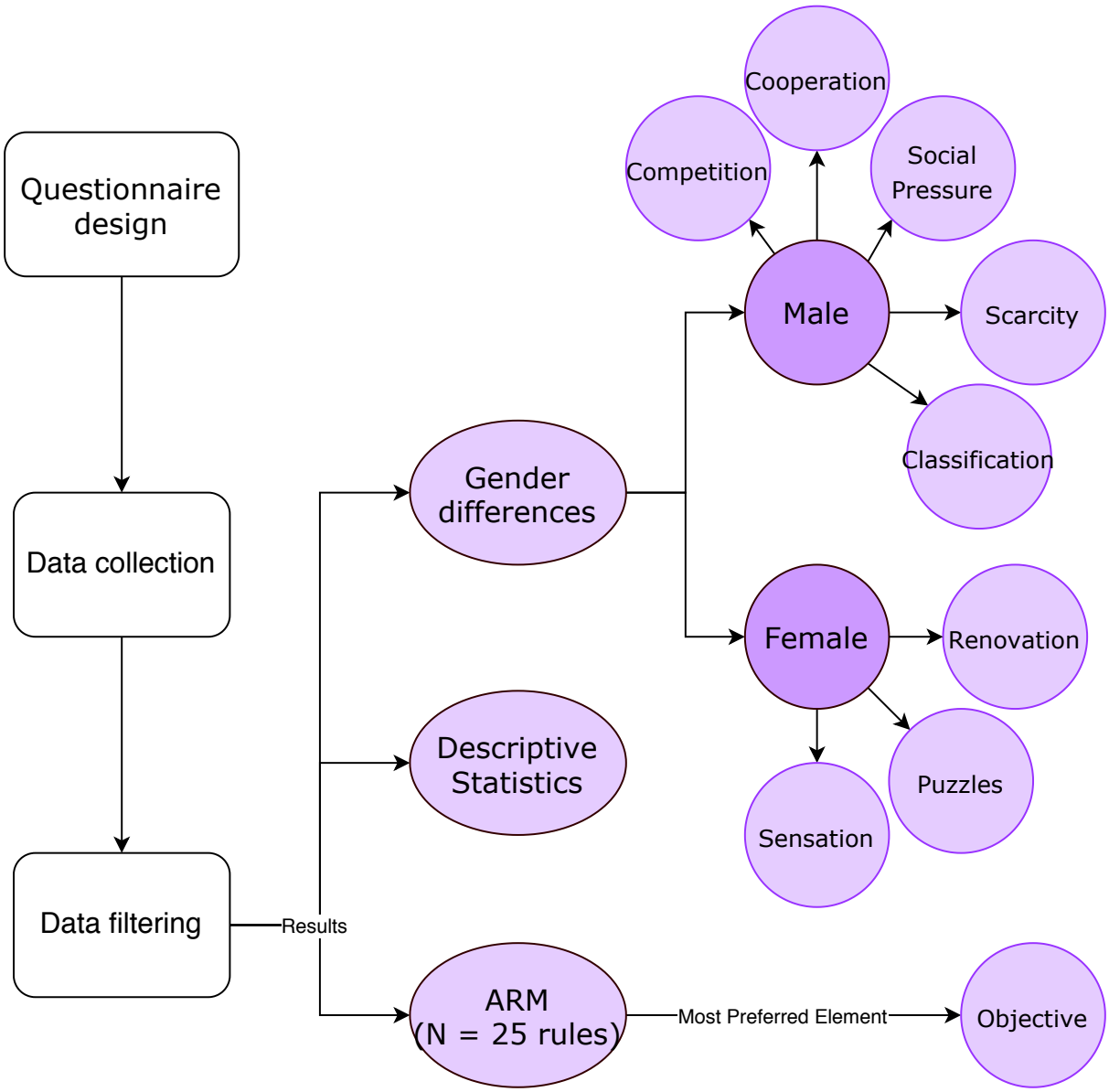

Figure 8 – Summary of our study presented in (TODA *et al.*, 2019c)

Through this study, we provided some evidence and insights on how students' gender can influence the gamification design. Through the rules that were found, we obtained an initial

[1] For more details on which criteria we used to define the relevance of our rules, see paper on Annex K

recommendation on how these gamification elements can be used, which allowed us to conduct two of the studies presented in this chapter.

4.2 Validating the effectiveness of data-driven gamification recommendations: An Exploratory study

In the following study, as an extension of the study presented in (TODA *et al.*, 2019c), we aimed to validate the recommendations provided by data-driven features by the students[2] (TODA *et al.*, 2019). Based on this premise, this work focused in answering the following *SRQj: How do users perceive game elements implemented in e-learning environments, based on prior research on data-driven gamification recommendations?*

To conduct this study, we analysed the rules that were presented in (TODA *et al.*, 2019c) and, with the aid of experts, designed 25 mockups on how the elements presented in the rule would be applied to a generic e-learning system. Them we created and applied a survey to verify the relevance of those elements in that context (of an e-learning system). The mockups were validated by experts in Human-Computer Interaction and the survey was validated by three experts in the field of gamification. More details on the survey creation and methods can be seen on Annex L.

We invited 50 people to answer our survey, however only 15 answered. The sample was distributed between 8 male students and 7 female students. Based on their answers, we found some insights: (a) users perceive Level and Progression as the same element; (b) Progression, Objectives, and Acknowledgement are usually well-perceived when tied together; (c) Choices and Data should be treated as inherent of the system and not gamification elements; (d) Points alone are not well-perceived, so it should be tied with other elements; (e) Acknowledgement is the most praised element, which means that creating meaningful achievements is a good strategy for e-learning environments.

In summary, we provided insights on how students perceive the gamification elements that are presented within an e-learning system. In this work we have shown small differences between males and females in terms of their perception of gamified elements. We also observed that female individuals preferred Progression element more than male individuals, while the second prefer Acknowledgement. This result is the opposite from prior findings in (TODA *et al.*, 2019c). However, Progression, Acknowledgement, and Objective are suitable for both genders, as suggested in the previous study. A summary of the study can be seen in Figure 9.

[2] We opted to choose students since they would be the final users of the gamification designs that were generated.

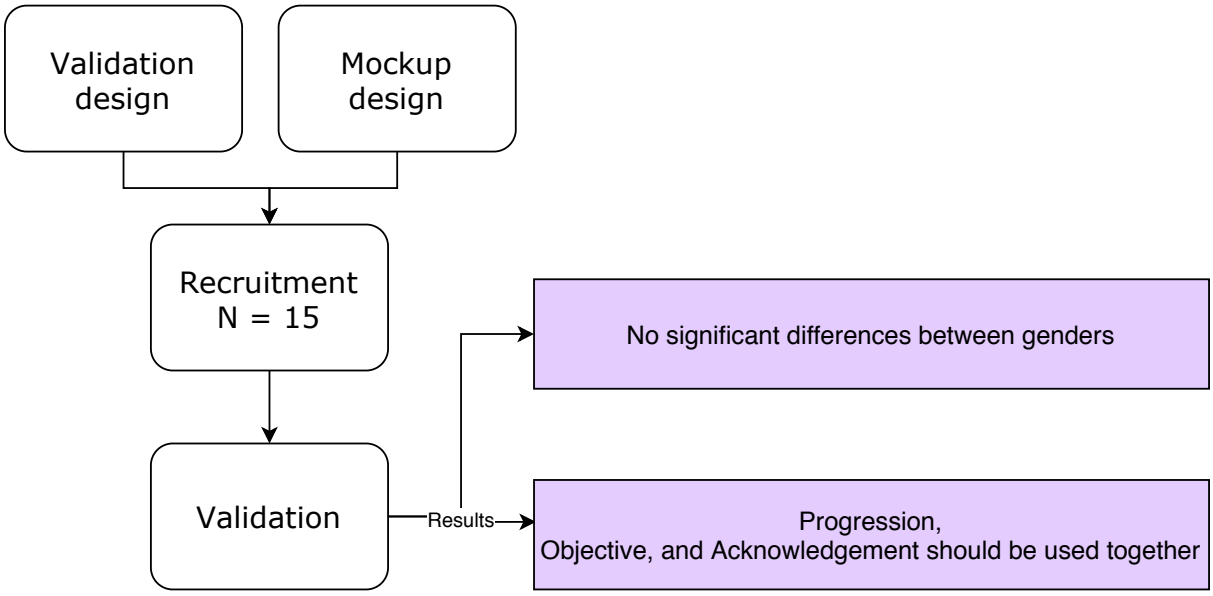

Figure 9 – Summary of (TODA *et al.*, 2019)

4.3 For whom should we gamify? Insights on the users intentions and context towards gamification in education

In this work, we aimed to identify how the users' characteristics could influence in their positive intention to use gamification (TODA *et al.*, 2020). To achieve this objective, we focused on answering the *SRQk: How users' demographics and contextual characteristics influence the positive intention towards gamification in education?*

In this exploratory study, we adopted a similar approach seen in (TODA *et al.*, 2019c). We created and conducted a survey (N = 1692 respondents) and analysed through a quantitative approach, applying ARM and clustering to identify patterns within the dataset so we can understand how the users' characteristics can or may influence in their adoption of gamification, specially in education domain.

In the first phase of the study, we designed a survey with 12 questions, aimed at characterising the user and asking their intentions to use gamification[3]. These intentions were measured through a Likert scale from 1 to 5, where we considered 1 a negative intention, and 5 a positive intention to use gamification in that specific domain[4].

Then, we used ARM analysis to find relevant information between the user characteristic and their intentions to use gamification, followed by clustering (K-means algorithm) to group these users and find patterns. To validate the number of clusters we used the knee-point detection

[3] More details on the survey can be seen on Annex M

[4] The domains that were analysed in this survey were Education, Work Environment, Health, and Daily Routine.

technique alongside the silhouette coefficient and found that 5 clusters would be the most appropriate for our analysis.

In the following phase, we processed the data to analyse with the aforementioned algorithms. Through our descriptive analysis, we identified that most of our respondents does not know the correct definition of gamification, which led us to infer that these respondents might not know how to identify a gamified application. When analysing their intentions to use, we can observe that 65,5% of our respondents have a positive intention to use gamification in education.

When analysing our Association Rules, we identified that people who usually play games, had previous contact with gamified applications and had previous knowledge on what gamification is have a positive intention to use it in education. We also identified that people who usually play games but did not have previous contact with gamification have neutral intention to use it in education. For our cluster analysis, we identified five groups:

- Cluster 1: People that are indifferent about gamification in education and have a negative intention towards other fields. The people in this group play games, knows what gamification is, but believe they did not had previous contact.
- Cluster 2: People who have positive intention to use gamification within all fields that were analysed, these people also had a previous contact with gamification, usually play games, and knows what gamification is.
- Cluster 3: People who have negative intention towards gamification, these people usually play games, but does not know what gamification is, believed they had no previous contact with gamification.
- Cluster 4: Is similar to Cluster 2, however it is almost balanced between people who believed they had previous contact with gamification.
- Cluster 5: People in this cluster have a positive intention to use gamification in education, however has a negative intention towards its use in work environments. Respondents here are people who usually play games, knows what gamification is, and had previous contact with gamification.

In summary, through this study, we provided some important contributions to the field, as: (a) evidence that context (previous knowledge, habit of playing games, and contact with gamification) influence the intention to use; (b) and evidence that specific demographic characteristics do not play a major role in the intention to use. A summary of our study can be seen on Figure 10.

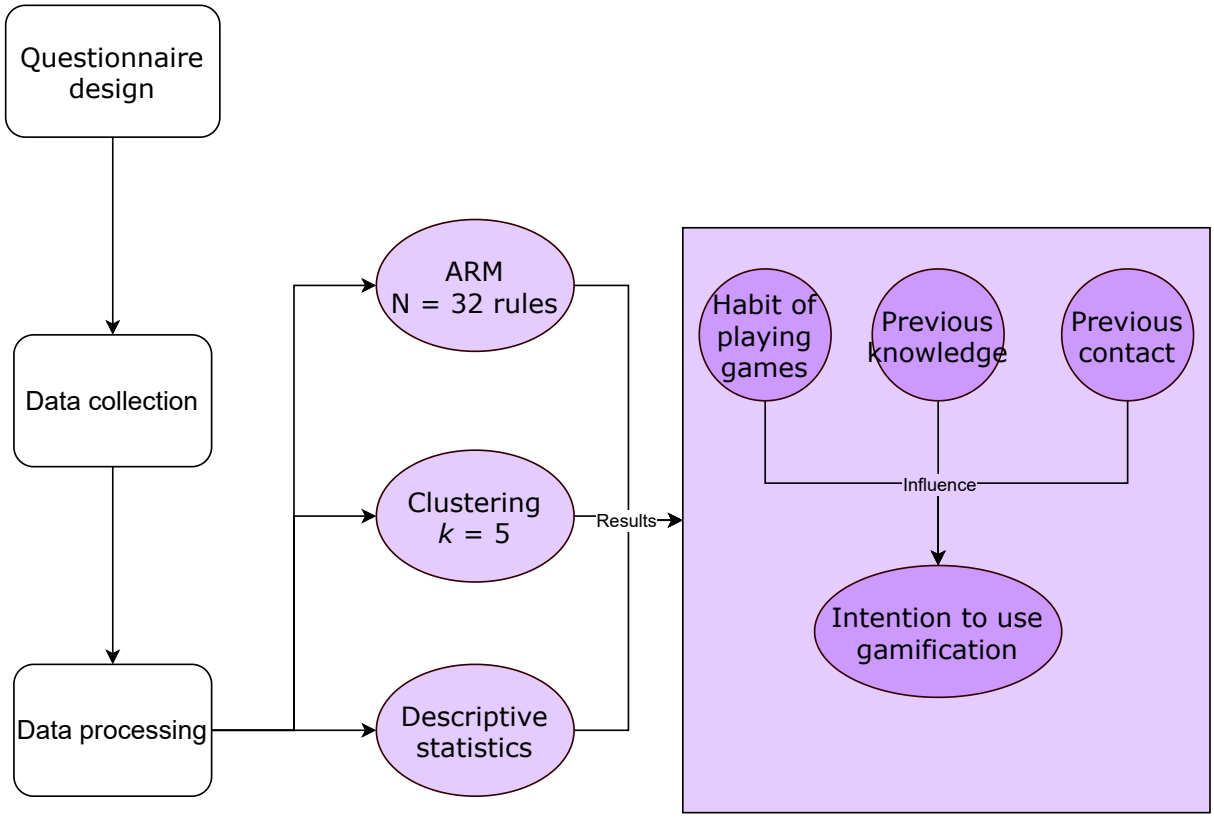

Figure 10 – Summary of our study

4.4 Final Remarks on this chapter

This chapter presented contributions made by the author to the data-driven gamification design, through answering different SRQs. In this sense, we provided a set of recommendations based on the users' gender (TODA *et al.*, 2019c) and validated those recommendations with students (TODA *et al.*, 2019). We also explored how contextual characteristics influenced in the positive intention towards gamification, and provided some insights for teachers and instructors on when and for whom they should try to gamify their practices (TODA *et al.*, 2020). Through this chapter we provided some answers to our SQ3 "How can we provide resources to the domain expert, to support the decision-making process of gamification design in educational contexts? ". These resources are materialised through data-driven gamified strategies, which were validated with real users, and conditions (on when and to whom) to gamifiy learning environments. The contributions of this chapter can be found in the Annex.

CHAPTER

5

FINAL REMARKS

This thesis aimed at answering our main research question “How can we contribute to the planning of gamification in educational contexts?”. We believe to have provided some answers to this question by presenting works that addressed many sub-research questions and gaps, divided in three sub-questions, each one dealing with a specific problem presented in the literature. Based on what has been exposed so far, we understand that gamification design is not a trivial task, and much has yet to be done, especially on the teachers / instructors’ side, which has mostly been neglected in the literature.

This Chapter provides an overall summary of the contributions provided by the author, focusing on a quantitative analysis of the achieved results. Besides, it also presents the authors’ participation in the scientific community, alongside future directions of research.

5.1 Overall contributions

In this thesis, we presented some contributions to support gamification design process, in theory and practice. We believe to have answered most of the questions that were proposed, and that our contributions had an impact in the field, and society. Through the studies conducted in this thesis, it is clear to us that gamification design is not something trivial that can be solved by an universal solution, many aspects are still needed to be considered in this process (such as culture and context) as well as whom is designing and applying it, specially in education.

Concerning our contributions in Chapter 2, we managed to provide evidence through secondary studies that listed negative effects and the elements associated to these effects; besides, we also presented the first taxonomy to describe gamification elements that can be used in educational domains, as well as the first model relating those gamification elements and cultural aspects. A summary of our contributions can be seen on Figure 11.

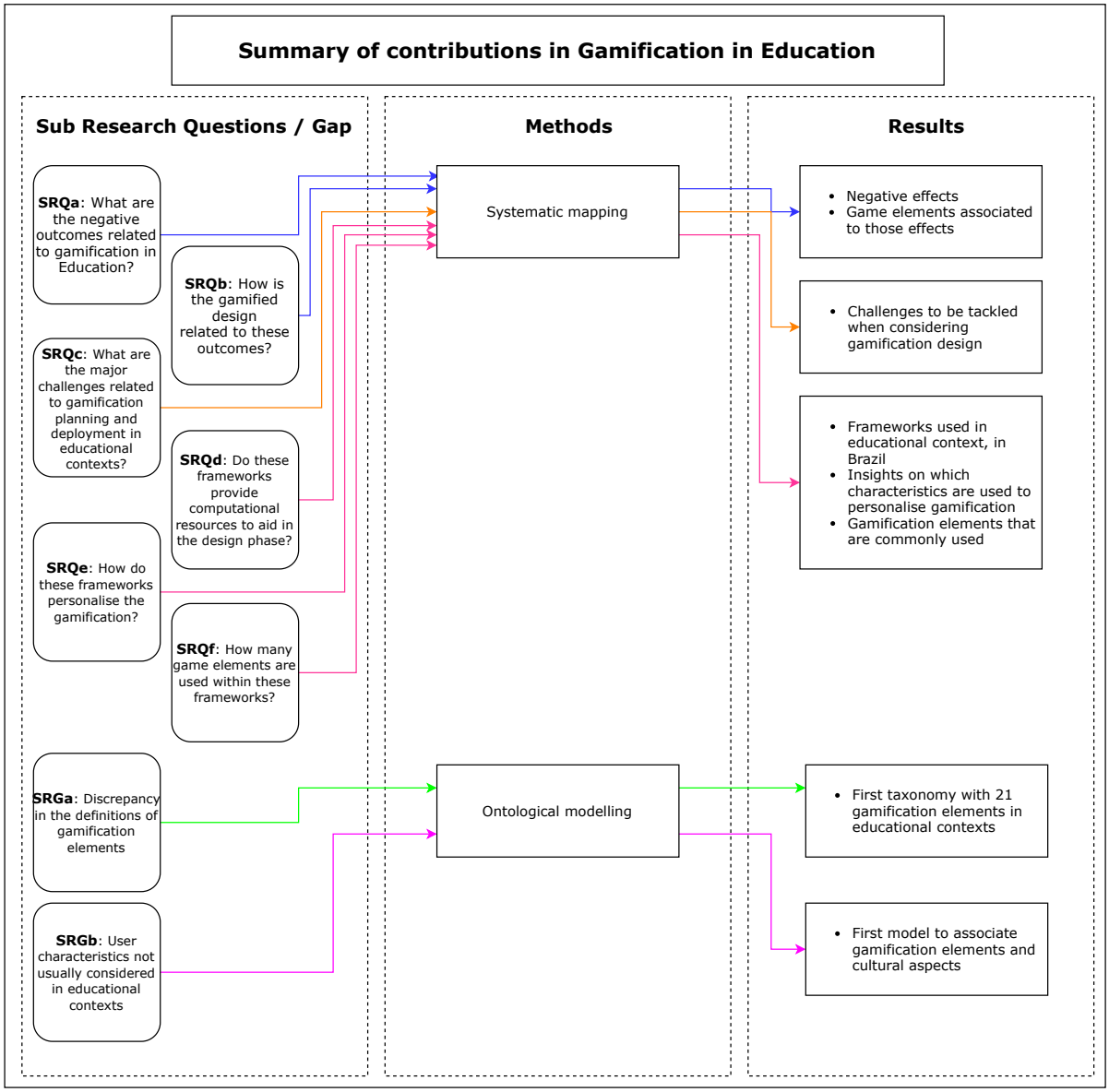

Figure 11 – Summary of contributions on Gamification in Education

Secondly, regarding the contributions that were presented in Chapter 3, we believe to be the first gamification framework focused on teachers and instructors. We presented the conception since its first process through case studies and its evolution to the final framework; we also presented alternative ways to use our proposed taxonomy to analyse and gamify learning systems, which could be useful to practitioners and researchers in this field. The summary of our contributions can be seen in Figure 12.

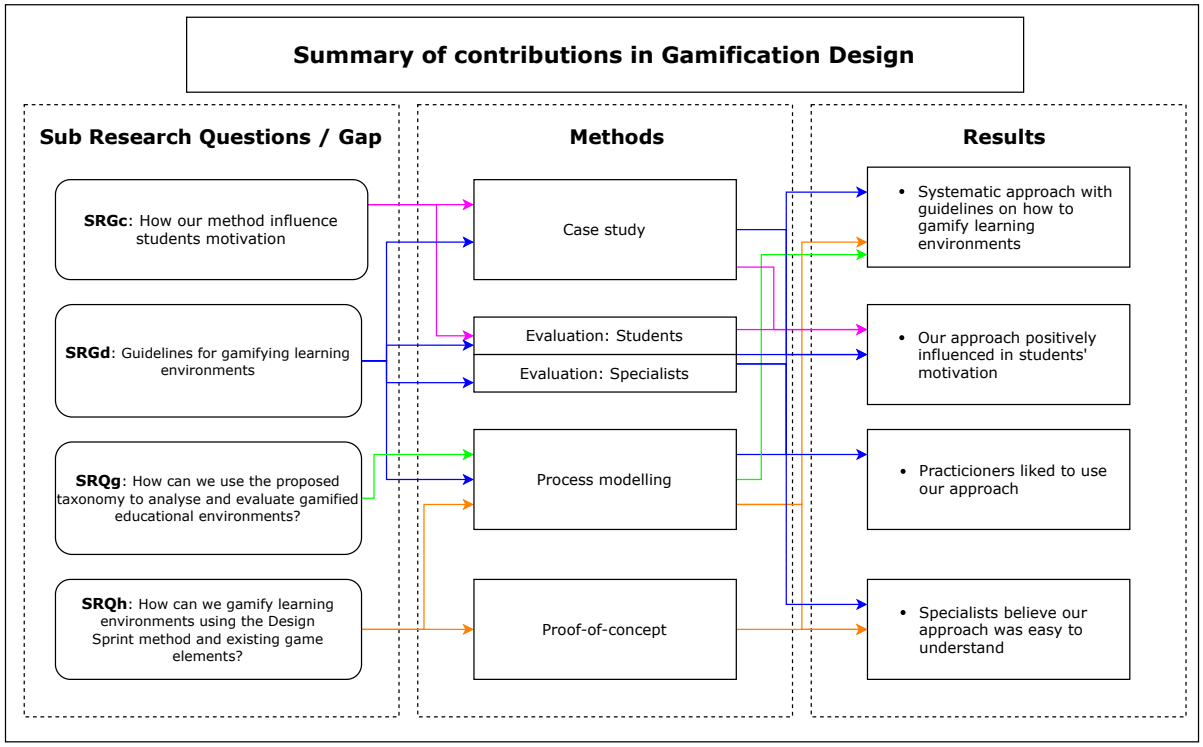

Figure 12 – Summary of contributions on Gamification Design

Finally, our contributions to the field of Data-driven gamification design consists in proposing strategies based on patterns that were mined through users' preferences. We also present how these patterns can be implemented through different mockups that were validate by students (final users), and insights on when and to whom gamify when considering learning environments. These contributions are summarised in Figure 13.

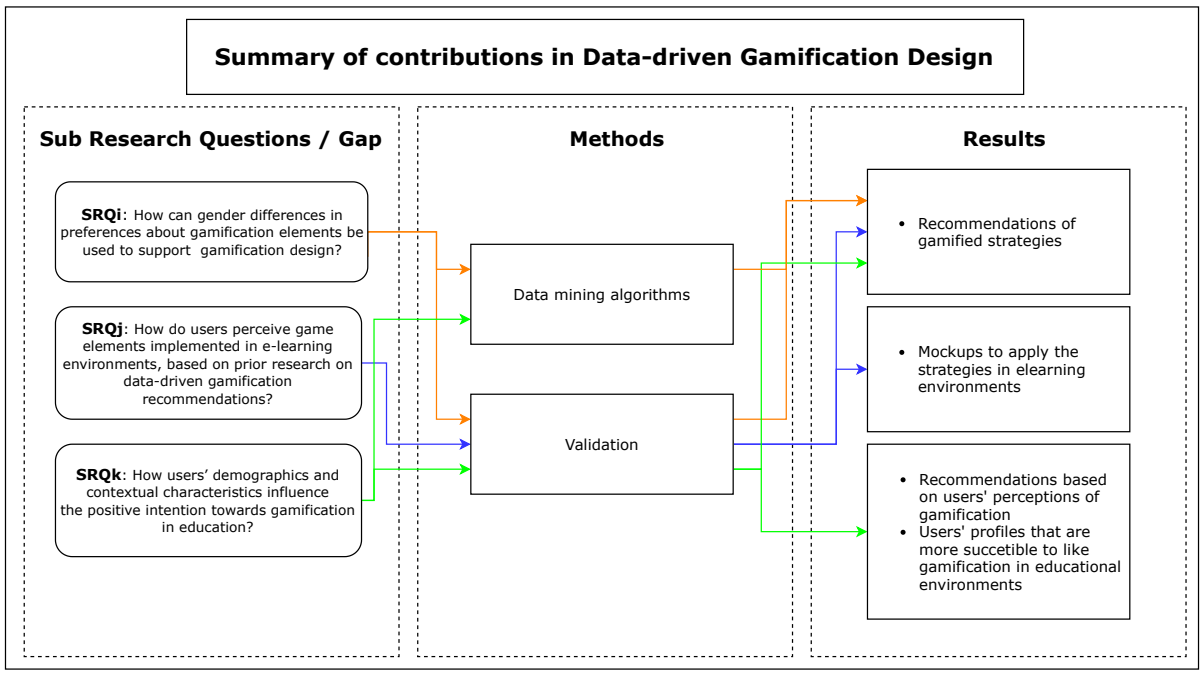

Figure 13 – Summary of contributions on Data-driven Gamification Design

5.2 Quantitative Analysis

Considering the scientific production, since 2016 (when the author entered the PhD program), the author published a total of 48 papers (until January/21), 33 in conferences, 14 in journals and 1 book Chapter. Figure 14 demonstrates the quantity of authors' publications throughout the years.

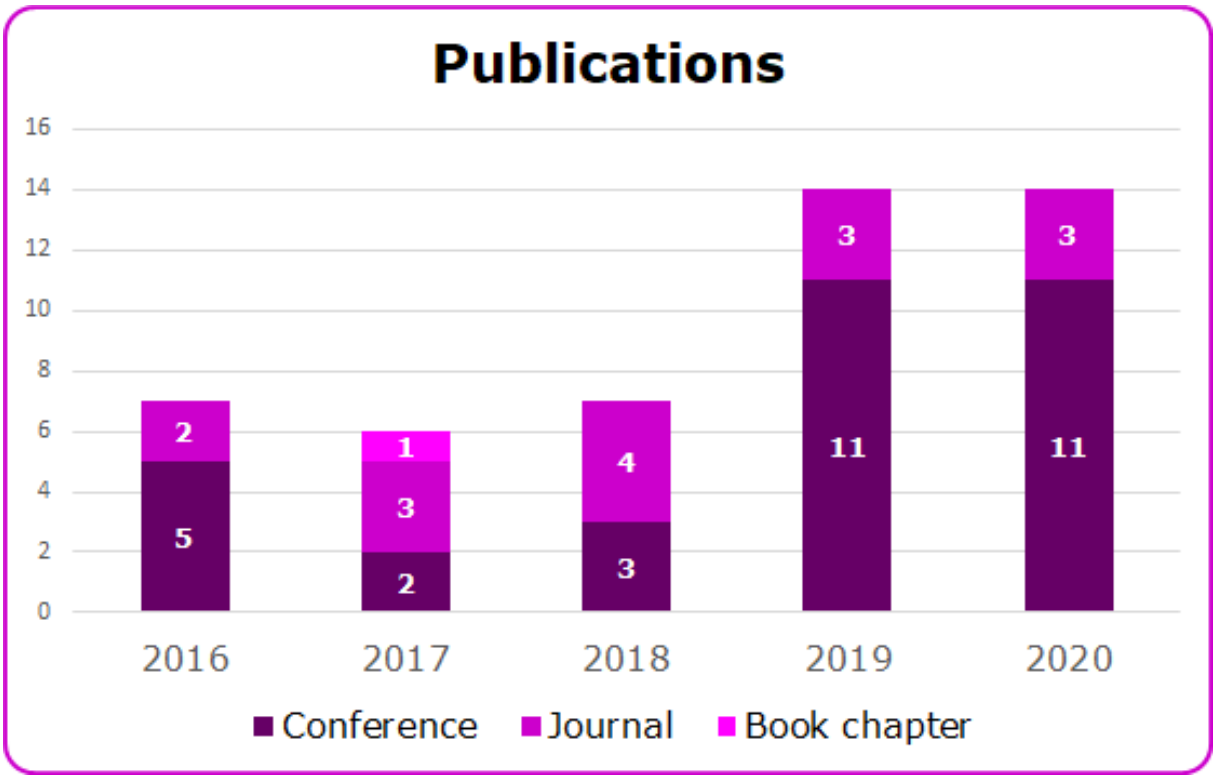

Figure 14 – Publications throughout the years, last updated on 10th, January/21

In Figure 14 it is possible to note an increase in the number of publications, specially in 2019 and 2020, that comprehends the period where the author went abroad to conduct part of their project in Durham University, in the United Kingdom, under the supervision of Professor Alexandra Ioana Cristea. Besides, the author also had a lot of collaborators with different universities in Brazil, ranging from North to South regions, including Federal University of Amazonas (UFAM), Federal University of Roraima (UFRR), Federal University of Pará (UFPA), University Center of Pará (CESUPA), Federal University of Rio Grande do Norte (UFRN), Federal University of Alagoas (UFAL), State University of Santa Catarina (UDESC), Federal University of Rio Grande do Sul (UFRGS). These contributions yield two prizes: Best paper award in the ICALT 19 conference, and second best paper on the track in the SBIE 20 conference. Another interesting information is regarding the authors' citations, which has been increasing throughout the years, especially since he joined the PhD program.

5.3 Scientific Community Participation

As stated previously, the author had many contributors scattered across Brazil, and the world. These contributions generated many highly relevant papers, and also contributed to the personal and academic growth of the author. Besides, the author also acted as reviewer for many important conferences and journals, some of them can be seen in Table 2.

Table 2 – Venues where the author was invited as reviewer

Name/Abbreviation	**Type**	**Relevance (Qualis)**
ACM Special Interest Group on Computer Science Education	Conference	A1
Hawaii International Conference on System Sciences	Conference	A1
Education Technology and Society	Journal	A1
International Conference on Artificial Intelligence in Education	Conference	A1
Frontiers in Education	Conference	A3
Simpósio Brasileiro de Informática na Educação	Conference	A3
Simpósio Brasileiro de Jogos e Entretenimento Digital	Conference	A4
International Journal of Emerging Technologies in Learning	Journal	A1
IEEE Transactions on Learning Technologies	Journal	A1

5.4 Limitations and Future perspectives

Throughout the course of this thesis, we found many challenges to overcome. Concerning the Gamification in Education studies, we can summarise that most of our limitations are related to protocols of systematic secondary studies (literature reviews and mappings). Since those studies are prone to many bias (e.g. the selection process of papers), we aimed to mitigate these bias by applying rigidly protocols proposed in the literature.

For the Gamification Design limitations, most were related to real environments challenges, e.g. the lecturer's time, technical difficulties with the strategies implemented in real-time, or unpredictability events during the academic semester, etc. However, events like these are prone to happen when conducting studies in real time scenarios, and case studies allow us to mitigate or be more flexible towards some of these events.

Finally, regarding the Data-driven Gamification Design limitations, we know that our recommendations may not be the most suitable, since students' preferences may not always be the best option. In this field specifically, our validation was delayed due to Covid-19 pandemic which hindered our experiments to examine the effectiveness of those strategies in real environments with teachers and students.

Based on the contributions presented so far, the author aims at continuing the research, to explore many of the gaps that still persist, towards improving the design of gamification in educational domains. One of these gaps is towards providing empirical evidence on the effectiveness of recommendations to teachers and instructors. This was present in our initial plans, however due to external factors (Covid-19 pandemic) we could not conduct all the evaluation we intended to. Besides, some of the products of this thesis might be submitted as patents, which is why some of them are not clearly described in this text. Another future perspective is to explore other variables that are often neglected, as culture (as we did in (TODA *et al.*, 2020)).

5.5 Conference Papers published as first author

- TODA, ARMANDO; PEREIRA, FILIPE DWAN ; KLOCK, ANA CAROLINA TOMÉ ; RODRIGUES, LUIZ ; PALOMINO, PAULA ; OLIVEIRA, WILK ; OLIVEIRA, ELAINE HARADA TEIXEIRA ; GASPARINI, ISABELA ; CRISTEA, ALEXANDRA IOANA ; ISOTANI, SEIJI . For whom should we gamify? Insights on the users intentions and context towards gamification in education. In: Simpósio Brasileiro de Informática na Educação, 2020, Brasil. Anais do XXXI Simpósio Brasileiro de Informática na Educação (SBIE 2020), 2020. p. 471.

- TODA, A. M.; SANTOS, W. O. ; SHI, L. ; BITTENCOURT, I. I. ; ISOTANI, S. ; CRISTEA, A. I. . Planning Gamification Strategies based on User Characteristics and DM: A Gender-based Case Study. In: Educational Data Mining 2019, 2019, Montréal. Proceedings of the 12th International Conference on Educational Data Mining, 2019.

- TODA, A. M.; SANTOS, W. O. ; KLOCK, A. C. T. ; PALOMINO, P. T. ; PIMENTA, M. ; GASPARINI, I. ; SHI, L. ; BITTENCOURT, I. I. ; ISOTANI, SEIJI ; CRISTEA, A. I. . A taxonomy of game elements for Gamification in educational contexts: Proposal and evaluation. In: 2019 IEEE 19th International Conference on Advanced Learning Technologies (ICALT), 2019, Maceió. Advanced Learning Technologies (ICALT), 2019 IEEE 19th International Conference on, 2019.

- TODA, ARMANDO; PALOMINO, PAULA ; RODRIGUES, LUIZ ; OLIVEIRA, WILK ; SHI, LEI ; ISOTANI, SEIJI ; CRISTEA, ALEXANDRA . Validating the Effectiveness of Data-Driven Gamification Recommendations: An Exploratory Study. In: XXX Simpósio Brasileiro de Informática na Educação (Brazilian Symposium on Computers in Education), 2019, Brasília. Anais do XXX Simpósio Brasileiro de Informática na Educação (SBIE 2019), 2019. p. 763.

- TODA, A. M.; SILVA, Y. R. O. ; CRUZ, W. M. ; XAVIER, L. ; ISOTANI, S. . Um processo de Gamificação para o ensino superior: Experiências em um módulo de Bioquímica. In: XXII Workshop de Informática na Escola, 2016, Uberlândia. Anais do WIE 2016, 2016

- TODA, A. M.; CARMO, R. M. C. ; SILVA, A. P. ; ISOTANI, SEIJI . GAMIFY-SN: A Meta-model for Planning and Deploying Gamification Concepts Within Social Networks - A Case Study. In: Álvaro Rocha;Hojjat Adeli;Luís Paulo Reis;Sandra Costanzo. (Org.). Trends and Advances in Information Systems and Technologies. WorldCIST'18 2018. Advances in Intelligent Systems and Computing. 1ed.: Springer, Cham, 2018, v. 2, p. 1357-1366.

- TODA, A. M.; FERREIRA, B. S. ; SANTOS, A. M. R. ; ISOTANI, S. ; MOREIRA, F. C. ; SANTOS, A. K. C. R. . Abordagens de ensino para Bioinformática: um mapeamento

sistemático. In: II Simpósio Norte-Nordeste de Bioinformática, 2017, Belém. II Simpósio Norte- Nordeste de Bioinformática, 2017.

- TODA, A. M.; ISOTANI, S. . Um processo para geração de designs gamificados para o ensino. In: I Workshop de Educação Digital e Interativa (WEDI), 2016, São José dos Campos. Anais do I Workshop de Educação Digital e Interativa (WEDI), 2016. v. 1.

5.6 Journals Papers and Book chapters published as first author

- Toda, Armando M.; KLOCK, ANA C. T. ; OLIVEIRA, WILK ; PALOMINO, PAULA T. ; RODRIGUES, LUIZ ; SHI, LEI ; BITTENCOURT, IG ; GASPARINI, ISABELA ; ISOTANI, SEIJI ; CRISTEA, ALEXANDRA I. . Analysing gamification elements in educational environments using an existing Gamification taxonomy. Smart Learning Environments, v. 6, p. 1-14, 2019.

- TODA, A. M.; PALOMINO, PAULA T. ; OLIVEIRA, W. ; RODRIGUES, LUIZ ; KLOCK, A. C. T. ; GASPARINI, ISABELA ; CRISTEA, A. I. ; ISOTANI, S. . How to Gamify Learning Systems? An Experience Report using the Design Sprint Method and a Taxonomy for Gamification Elements in Education. EDUCATIONAL TECHNOLOGY & SOCIETY, v. 22, p. 47-60, 2019.

- TODA, A. M.; SILVA, A. P. ; ISOTANI, S. . Desafios para o planejamento e implantação da gamificação no contexto educacional. RENOTE. REVISTA NOVAS TECNOLOGIAS NA EDUCAÇÃO, v. 15, p. 29, 2018.

- Toda, Armando M.; DO CARMO, RICARDO M.C. ; DA SILVA, ALAN P. ; BITTENCOURT, IG I. ; ISOTANI, SEIJI . An approach for planning and deploying gamification concepts with social networks within educational contexts. INTERNATIONAL JOURNAL OF INFORMATION MANAGEMENT, v. 46, p. 294-303, 2018.

- TODA, A. M.; SANTOS, W. O. ; KLOCK, A. C. T. ; GASPARINI, I. ; BITTENCOURT, I. I. ; ISOTANI, S. . Frameworks para o Planejamento da Gamificação em Contextos Educacionais - Uma revisão da literatura nacional. RENOTE. REVISTA NOVAS TECNOLOGIAS NA EDUCAÇÃO, v. 16, p. 1, 2018.

- TODA, A. M.; VALLE, P. H. D. ; GUESSI, M. ; ROCHA, R. V. ; MALDONADO, J. C. ; ISOTANI, S. . Plataforma de Recursos Educacionais Abertos: Uma Arquitetura de Referência com Elementos de Gamificação. RENOTE. Revista Novas Tecnologias na Educação, v. 14, p. 1-10, 2016.

- Toda, Armando M.; Valle, Pedro H. D. ; ISOTANI, SEIJI . The Dark Side of Gamification: An Overview of Negative Effects of Gamification in Education. In: Alexandra Ioana Cristea; Ig Ibert Bittencourt; Fernanda Lima. (Org.). Communications in Computer and Information Science. 832ed.: Springer International Publishing, 2018, v. , p. 143-156.

5.7 Conference Papers published as coauthor

- OLIVEIRA, W. ; TODA, A. M. ; PALOMINO, P. T. ; SHI, L. ; VASSILEVA, J. ; BITTENCOURT, IG I. ; ISOTANI, SEIJI . Does Tailoring Gamified Educational Systems Matter? The Impact on Students' Flow Experience. In: 53rd Hawaii International Conference on System Sciences 2020, 2020, Havaí. Proceedings of the 53rd Hawaii International Conference on System Sciences 2020, 2020.

- RODRIGUES, LUIZ ; Toda, Armando M. ; OLIVEIRA, WILK ; PALOMINO, PAULA T. ; ISOTANI, SEIJI . Just beat it: Exploring the influences of competition and task-related factors in gamified learning environments. In: Simpósio Brasileiro de Informática na Educação, 2020, Brasil. Anais do XXXI Simpósio Brasileiro de Informática na Educação (SBIE 2020), 2020. p. 461.

- OLIVEIRA, WILK ; Toda, Armando M. ; PALOMINO, PAULA T. ; RODRIGUES, LUIZ ; SHI, LEI ; ISOTANI, SEIJI . Towards Automatic Flow Experience Identification in Educational Systems: A Qualitative Study. In: Simpósio Brasileiro de Informática na Educação, 2020, Brasil. Anais do XXXI Simpósio Brasileiro de Informática na Educação (SBIE 2020), 2020. p. 702.

- SOUZA, JOSEANE ; OLIVEIRA, FABIANA ; SILVA, LAÍZA ; TODA, ARMANDO ; ISOTANI, SEIJI . The impact of serious games on the learning of students with Autism Spectrum Disorder. In: Workshop de Informática na Escola, 2020, Brasil. Anais do XXVI Workshop de Informática na Escola (WIE 2020), 2020. p. 459.

- PALOMINO, P. T. ; TODA, A. M. ; RODRIGUES, LUIZ ; OLIVEIRA, W. ; ISOTANI, SEIJI . From the Lack of Engagement to Motivation: Gamification Strategies to Enhance Users Learning Experiences. In: XIX SBGames, 2020, Recife. Proceedings of SBGames 2020, 2020. p. 1127-1130.

- RODRIGUES, LUIZ ; TODA, A. M. ; PALOMINO, PAULA T. ; OLIVEIRA, WILK ; ISOTANI, SEIJI . Personalized gamification: A literature review of outcomes, experiments, and approaches. In: 8th International Conference on Technological Ecosystems for Enhancing Multiculturality (TEEM 2020), 2020, Salamanca. Proceedings of the 8th International Conference on Technological Ecosystems for Enhancing Multiculturality (TEEM 2020), 2020.

- SHI, L. ; SANTOS, W. O. ; TODA, A. M. ; CRISTEA, A. I. . Revealing the Hidden Patterns: A Comparative Study on Profiling Subpopulations of MOOC Students. In: 28TH INTERNATIONAL CONFERENCE ON INFORMATION SYSTEMS DEVELOPMENT, 2019, Toulon. 28TH INTERNATIONAL CONFERENCE ON INFORMATION SYSTEMS DEVELOPMENT, 2019.

- PALOMINO, PAULA ; TODA, ARMANDO ; OLIVEIRA, WILK ; RODRIGUES, LUIZ ; CRISTEA, ALEXANDRA ; ISOTANI, SEIJI . Exploring content game elements to support gamification design in educational systems: narrative and storytelling. In: XXX Simpósio Brasileiro de Informática na Educação (Brazilian Symposium on Computers in Education), 2019, Brasília. Anais do XXX Simpósio Brasileiro de Informática na Educação (SBIE 2019), 2019. p. 773.

- OLIVEIRA, WILK ; RODRIGUES, LUIZ ; TODA, ARMANDO ; PALOMINO, PAULA ; ISOTANI, SEIJI . Automatic Game Experience Identification in Educational Games. In: XXX Simpósio Brasileiro de Informática na Educação (Brazilian Symposium on Computers in Education), 2019, Brasília. Anais do XXX Simpósio Brasileiro de Informática na Educação (SBIE 2019), 2019. p. 952.

- RODRIGUES, LUIZ ; OLIVEIRA, WILK ; TODA, ARMANDO ; PALOMINO, PAULA ; ISOTANI, SEIJI . Thinking Inside the Box: How to Tailor Gamified Educational Systems Based on Learning Activities Types. In: XXX Simpósio Brasileiro de Informática na Educação (Brazilian Symposium on Computers in Education), 2019, Brasília. Anais do XXX Simpósio Brasileiro de Informática na Educação (SBIE 2019), 2019. p. 823.

- SILVA, FERNANDO ; TODA, ARMANDO ; ISOTANI, SEIJI . Towards a link between Instructional Approaches and Gamification - A Case Study in a Programming Course. In: XXIV Workshop de Informática na Escola, 2018, Fortaleza, 2018. p. 157.

- RIBEIRO SILVA, LAIZA ; PEDRO DA SILVA, ALAN ; TODA, ARMANDO ; ISOTANI, SEIJI . Impact of Teaching Approaches to Computational Thinking on High School Students: A Systematic Mapping. In: 2018 IEEE 18th International Conference on Advanced Learning Technologies (ICALT), 2018, Mumbai. 2018 IEEE 18th International Conference on Advanced Learning Technologies (ICALT), 2018. p. 285.

- VALLE, P. H. D. ; TODA, A. M. ; BARBOSA, E. F. ; MALDONADO, J. C. . Educational Games: A Contribution to Software Testing Education. In: Annual Frontiers in Education (FIE), 2017, Indianapolis. 47th Annual Frontiers in Education (FIE), 2017.

- PALOMINO, P. T. ; TODA, A. M. ; SANTOS, W. O. ; CRISTEA, A. I. ; ISOTANI, SEIJI . Narrative for gamification in education: why should you care?. In: 2019 IEEE 19th International Conference on Advanced Learning Technologies (ICALT), 2019, Maceió.

Advanced Learning Technologies (ICALT), 2019 IEEE 19th International Conference on, 2019.

- OLIVEIRA, WILK ; TODA, ARMANDO ; PALOMINO, PAULA ; RODRIGUES, LUIZ ; ISOTANI, SEIJI ; SHI, LEI . Towards Automatic Flow Experience Identification in Educational Systems. In: Extended Abstracts of the Annual Symposium, 2019, Barcelona. Extended Abstracts of the Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts - CHI PLAY '19 Extended Abstracts, 2019. p. 581.

5.8 Journals Papers and Book chapters published as coauthor

- PEREIRA, FILIPE D. ; OLIVEIRA, ELAINE H. T. ; OLIVEIRA, DAVID B. F. ; CRISTEA, ALEXANDRA I. ; CARVALHO, LEANDRO S. G. ; FONSECA, SAMUEL C. ; TODA, ARMANDO ; ISOTANI, SEIJI . Using learning analytics in the Amazonas: understanding students? behaviour in introductory programming. British Journal of Educational Technology, v. 51, p. 955-972, 2020.

- OLIVEIRA, W. ; TODA, A. M. ; PALOMINO, PAULA T. ; RODRIGUES, LUIZ ; ISOTANI, SEIJI . Which one is the best? A quasi-experimental study comparing frameworks for unplugged gamification. RENOTE. REVISTA NOVAS TECNOLOGIAS NA EDUCAÇÃO, v. 18, p. 1, 2020.

- T. PALOMINO, PAULA ; M. TODA, ARMANDO ; OLIVEIRA, WILK ; RODRIGUES, LUIZ ; ISOTANI, SEIJI . Teaching Interactive Fiction for Undergraduate Students with the Aid of Information Technologies: An Experience Report. RENOTE. REVISTA NOVAS TECNOLOGIAS NA EDUCAÇÃO, v. 17, p. 527-536, 2019.

- SANTOS, W. O. ; TODA, A. M. ; ISOTANI, S. ; BITTENCOURT, I. I. . Does Gamified Educational Systems Change Students? Learning Behaviors? A Case Study with Postgraduate Students. RENOTE. REVISTA NOVAS TECNOLOGIAS NA EDUCAÇÃO, v. 16, p. 1, 2018.

- DE OLIVEIRA SILVA, YURI RAFAEL ; MACIEL TODA, ARMANDO ; ISOTANI, SEIJI ; PEREIRA XAVIER, LUCIANA . Uso de gamificação em aulas de Bioquímica como ferramenta de engajamento e motivação no ensino superior. REVISTA DE ENSINO DE BIOQUÍMICA, v. 15, p. 178, 2017.

- SHI, LEI ; CRISTEA, ALEXANDRA I. ; Toda, Armando M. ; OLIVEIRA, WILK . Exploring Navigation Styles in a FutureLearn MOOC. Lecture Notes in Computer Science. ITSed.: Springer International Publishing, 2020, v. , p. 45-55.

- PEREIRA, FILIPE D. ; TODA, ARMANDO ; OLIVEIRA, ELAINE H. T. ; CRISTEA, ALEXANDRA I. ; ISOTANI, SEIJI ; Laranjeira, Dion ; Almeida, Adriano ; Mendonça, Jonas . Can We Use Gamification to Predict Students Performance? A Case Study Supported by an Online Judge. Lecture Notes in Computer Science. ITSed.: Springer International Publishing, 2020, v. , p. 259-269.

BIBLIOGRAPHY

AGRAWAL, R.; IMIELIŃSKI, T.; SWAMI, A. **Mining association rules between sets of items in large databases**. New York, New York, USA: ACM Press, 1993. 207–216 p. Available: <http://portal.acm.org/citation.cfm?doid=170035.170072http://www.vamsitalkstech.com/?p=2612>. Citations on pages 27 and 28.

ALMARSHEDI, A.; WANICK, V.; WILLS, G. B. Gamification and Behaviour. In: **Gamification**. [S.l.: s.n.], 2016. p. 3–18. ISBN 978-3-319-45555-6. Citation on page 39.

ALPAYDIN, E. **Introduction to machine learning**. [S.l.]: MIT press, 2020. Citation on page 27.

AN, Y.; ZHU, M.; BONK, C. J.; LIN, L. Exploring instructors' perspectives, practices, and perceived support needs and barriers related to the gamification of MOOCs. **Journal of Computing in Higher Education**, Springer, p. 1–21, jun 2020. ISSN 18671233. Available: <http://link.springer.com/10.1007/s12528-020-09256-w>. Citations on pages 23, 24, and 26.

AYUB, M.; TOBA, H.; WIJANTO, M. C.; YONG, S.; WIJAYA, B. Gamification for blended learning in higher education. **World Transactions on Engineering and Technology Education**, World Institute for Engineering and Technology Education (WIETE), v. 17, n. 1, p. 76–81, 2019. Citation on page 28.

BORGES, S. d. S.; DURELLI, V. H. S.; REIS, H. M.; ISOTANI, S. A systematic mapping on gamification applied to education. In: **Proceedings of the 29th Annual ACM Symposium on Applied Computing - SAC '14**. [s.n.], 2014. p. 216–222. ISBN 9781450324694. Available: <http://dl.acm.org/citation.cfm?doid=2554850.2554956>. Citation on page 25.

BUCKLEY, J.; DEWILLE, T.; EXTON, C.; EXTON, G.; MURRAY, L. A Gamification–Motivation Design Framework for Educational Software Developers. **Journal of Educational Technology Systems**, SAGE PublicationsSage CA: Los Angeles, CA, v. 47, n. 1, p. 004723951878315, sep 2018. ISSN 0047-2395. Available: <http://journals.sagepub.com/doi/10.1177/0047239518783153>. Citation on page 24.

CARUSO, G.; GATTONE, S. A.; FORTUNA, F.; Di Battista, T. Cluster analysis as a decision-making tool: a methodological review. In: SPRINGER. **International Symposium on Distributed Computing and Artificial Intelligence**. [S.l.], 2017. p. 48–55. Citation on page 28.

CHOU, Y.-K. **Actionable gamification: Beyond points, badges, and leaderboards**. [s.n.], 2012. 509 p. ISSN 1098-6596. ISBN 9788578110796. Available: <https://leanpub.com/actionable-gamification-beyond-points-badges-leaderboards/read>. Citation on page 26.

da Silva Hanzelmann, R.; PEREIRA, É. A. A.; VELASCO, A. R.; SILVA, A. S. da; OLIVEIRA, E. B. de; PASSOS, J. P. Estresse do professor do Ensino Fundamental: o ambiente em evidência. **Research, Society and Development**, v. 9, n. 8, p. e53982910—-e53982910, 2020. Citations on pages 25 and 26.

DAREJEH, A.; SALIM, S. S. Gamification Solutions to Enhance Software User Engagement – A Systematic Review. **International Journal of Human-Computer Interaction**, v. 7318, n. May, p. 10447318.2016.1183330, 2016. ISSN 1044-7318. Available: <http://www.tandfonline.com/doi/full/10.1080/10447318.2016.1183330>. Citations on pages 25 and 44.

DE-MARCOS, L.; GARCIA-LOPEZ, E.; GARCIA-CABOT, A. On the Effectiveness of Game-like and Social Approaches in Learning: Comparing Educational Gaming, Gamification & Social Networking. **Computers & Education**, Elsevier Ltd, v. 95, p. 99–113, dec 2015. ISSN 03601315. Available: <http://www.sciencedirect.com/science/article/pii/S0360131515300981http://www.scopus.com/inward/record.url?eid=2-s2.0-84954288877{&}partnerID=tZOtx3y1>. Citation on page 45.

DECI, E. L.; RYAN, R. M. **Intrinsic Motivation and Self-Determination in Human Behavior**. Boston, MA: Springer US, 1985. ISBN 978-1-4899-2273-1. Available: <http://link.springer.com/10.1007/978-1-4899-2271-7>. Citation on page 44.

DETERDING, S.; SICART, M.; NACKE, L.; O'HARA, K.; DIXON, D. From Game Design Elements to Gamefulness: Defining "Gamification". **Proceedings of the 2011 annual conference extended abstracts on Human factors in computing systems - CHI EA '11**, p. 2425, 2011. ISSN 1450308163. Available: <http://www.scopus.com/inward/record.url?eid=2-s2.0-79957930613{&}partnerID=tZOtx3y1>. Citations on pages 23 and 24.

DICHEV, C.; DICHEVA, D. **Gamifying education: what is known, what is believed and what remains uncertain: a critical review**. Nature Publishing Group, 2017. 9 p. Available: <http://educationaltechnologyjournal.springeropen.com/articles/10.1186/s41239-017-0042-5>. Citations on pages 23, 24, 26, and 31.

DICHEVA, D.; DICHEV, C. Gamification in Education: Where Are We in 2015? **E-Learn 2015 - Kona, Hawaii, United States**, n. July 2014, p. 1445–1454, 2015. Citation on page 24.

FERNANDES, G. C. P. S.; VANDENBERGUE, L. O estresse, o professor e o trabalho docente. Revista LABOR, 2018. Citation on page 25.

GARTNER. **Gartner Says By 2015, More Than 50 Percent of Organizations That Manage Innovation Processes Will Gamify Those Processes**. 2011. Available: <http://www.gartner.com/newsroom/id/1629214>. Citation on page 24.

GHAHRAMANI, Z. Unsupervised learning. In: SPRINGER. **Summer School on Machine Learning**. [S.l.], 2003. p. 72–112. Citation on page 27.

HOFSTEDE, G. Dimensionalizing cultures: The Hofstede model in context. **Online readings in psychology and culture**, International Association for Cross-Cultural Psychology, v. 2, n. 1, p. 8, 2011. Citation on page 39.

ISOTANI, S.; BITTENCOURT, I. I. **Dados Abertos Conectados**. Novatec, 2015. 175 p. ISSN 24470821. ISBN 978-85-7522-449-6. Available: <http://ceweb.br/livros/dados-abertos-conectados/>. Citation on page 39.

KAPP, K. M. The Gamification of Learning and Instruction: Game-based Methods and Strategies for Training and Education. Pfeiffer & Company, may 2012. Available: <http://dl.acm.org/citation.cfm?id=2378737>. Citations on pages 25 and 31.

KITCHENHAM, B.; Pearl Brereton, O.; BUDGEN, D.; TURNER, M.; BAILEY, J.; LINKMAN, S. **Systematic literature reviews in software engineering - A systematic literature review**. 2009. 7–15 p. Available: <http://iranarze.ir/wp-content/uploads/2015/02/software-engineering-Systematic-reviews.pdf>. Citation on page 31.

KLOCK, A. C. T.; GASPARINI, I.; PIMENTA, M. S.; HAMARI, J. Tailored gamification: A review of literature. **International Journal of Human-Computer Studies**, Academic Press, p. 102495, jun 2020. ISSN 1071-5819. Available: <https://www.sciencedirect.com/science/article/pii/S1071581920300975>. Citations on pages 23, 25, and 39.

KOIVISTO, J.; HAMARI, J. **The rise of motivational information systems: A review of gamification research**. Pergamon, 2019. 191–210 p. Available: <https://www.sciencedirect.com/science/article/pii/S0268401217305169>. Citations on pages 27 and 34.

LEE, J. J.; HAMMER, J. Gamification in Education: What, How, Why Bother? **Academic Exchange Quarterly**, v. 15, p. 1–5, 2011. Available: <http://dialnet.unirioja.es/servlet/articulo?codigo=3714308>. Citation on page 23.

LIKERT, R. A technique for the measurement of attitudes. **Archives of Psychology**, v. 140, n. 140, p. 44–53, 1932. Available: <http://psycnet.apa.org/record/1933-01885-001>. Citation on page 44.

M. Toda, A.; Henrique Dias Valle, P.; GUESSI, M.; Vilela da Rocha, R.; Carlos Maldonado, J.; ISOTANI, S.; ISOTANI, S. Plataforma de Recursos Educacionais Abertos: Uma Arquitetura de Referência com Elementos de Gamificação. **RENOTE**, v. 14, n. 2, jan 2017. ISSN 1679-1916. Available: <http://seer.ufrgs.br/index.php/renote/article/view/70650>. Citation on page 25.

MARTÍ-PARREÑO, J.; SEGUÍ-MAS, D.; SEGUÍ-MAS, E. Teachers' Attitude towards and Actual Use of Gamification. **Procedia - Social and Behavioral Sciences**, v. 228, p. 682–688, jul 2016. ISSN 18770428. Available: <http://linkinghub.elsevier.com/retrieve/pii/S1877042816310308>. Citations on pages 23 and 25.

MCDANIEL, R.; FANFARELLI, J. Building Better Digital Badges: Pairing Completion Logic With Psychological Factors. **Simulation & Gaming**, v. 47, n. 1, p. 73–102, feb 2016. ISSN 1046-8781. Available: <http://sag.sagepub.com/content/47/1/73.abstract>. Citation on page 28.

MEDER, M.; PLUMBAUM, T.; ALBAYRAK, S. A Primer on Data-Driven Gamification Design. In: **Proceedings of the Data-Driven Gamification Design Workshop**. [s.n.], 2017. Available: <https://pdfs.semanticscholar.org/c8dd/744530be00bc3b12046b60facb4b1bd47137.pdf>. Citation on page 27.

MORA, A.; RIERA, D.; GONZALEZ, C.; ARNEDO-MORENO, J. A Literature Review of Gamification Design Frameworks. In: **2015 7th International Conference on Games and Virtual Worlds for Serious Applications (VS-Games)**. IEEE, 2015. p. 1–8. ISBN 978-1-4799-8102-1. Available: <http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=7295760>. Citation on page 45.

MORA, A.; RIERA, D.; GONZÁLEZ, C.; ARNEDO-MORENO, J. Gamification: a systematic review of design frameworks. **Journal of Computing in Higher Education**, 2017. ISSN 1042-1726. Available: <http://link.springer.com/10.1007/s12528-017-9150-4>. Citations on pages 24, 26, and 45.

NELSON, M. J. M. Soviet and American precursors to the gamification of work. **Proceeding of the 16th international academic MindTrek conference (pp. 23-26)**, ACM Press, New York, p. 23–26, 2012. Available: <http://dl.acm.org/citation.cfm?id=2393138>. Citation on page 24.

OLIVEIRA, W.; TODA, A. M.; PALOMINO, P. T.; RODRIGUES, L.; ISOTANI, S. Which one is the best? A quasi-experimental study comparing frameworks for unplugged gamification. **RENOTE**, v. 18, n. 1, 2020. Citation on page 27.

PALOMINO, P. T.; TODA, A.; OLIVEIRA, W.; RODRIGUES, L.; CRISTEA, A. I.; ISOTANI, S. Exploring Content Game Elements to Support Gamification Design in Educational Systems : Narrative and Storytelling. In: **Proceedings of the SBIE 2019**. Brasilia: [s.n.], 2019. p. 773 – 782. Citation on page 28.

PEREIRA, F. D.; TODA, A.; OLIVEIRA, E. H. T.; CRISTEA, A. I.; ISOTANI, S.; LARANJEIRA, D.; ALMEIDA, A.; MENDONÇA, J. Can We Use Gamification to Predict Students' Performance? A Case Study Supported by an Online Judge. In: SPRINGER. **International Conference on Intelligent Tutoring Systems**. [S.l.], 2020. p. 259–269. Citation on page 28.

PRENSKY, M. **Digital Game-based Learning**. New York: McGraw-Hill, 2003. ISSN 15443574. Available: <http://portal.acm.org/citation.cfm?doid=950566.950596http://www.amazon.com/Digital-Game-Based-Learning-Marc-Prensky/dp/1557788634/ref=sr{_}1{_}3?ie=UTF8{&}qid=1396875803{&}sr=8-3{&}keywords=Prensky>. Citation on page 23.

RAJANEN, D.; RAJANEN, M. Personalized gamification: A model for play data profiling. In: **CEUR Workshop Proceedings**. [s.n.], 2017. v. 1978, p. 26–33. ISBN 1531-5037 (Electronic)\r0022-3468 (Linking). ISSN 16130073. Available: <http://ceur-ws.org>. Citation on page 28.

RAUSCHENBERGER, M.; WILLEMS, A.; TERNIEDEN, M.; THOMASCHEWSKI, J. Towards the use of gamification frameworks in learning environments. **Journal of Interactive Learning Research**, Association for the Advancement of Computing in Education (AACE), v. 30, n. 2, p. 147–165, 2019. Citation on page 26.

SÁNCHEZ-MENA, A.; MARTÍ-PARREÑO, J. Gamification in higher education: teachers' drivers and barriers. **Proceedings of the International Conference of The Future of Education**, n. July, 2016. Citations on pages 23 and 25.

SANTOS, W. dos; BITTENCOURT, I.; VASSILEVA, J. Gamification Design to Tailor Gamified Educational Systems Based on Gamer Types. **Anais dos Workshops do Congresso Brasileiro de Informática na Educação 2018**, v. 7, n. 1, p. 42, oct 2018. ISSN 2316-8889. Available: <http://br-ie.org/pub/index.php/wcbie/article/view/8208https://www.researchgate.net/profile/Wilk{_}Oliveira{_}Dos{_}Santos/publication/328703707{_}Gamification{_}Design{_}to{_}Tailor{_}Gamified{_}Educational{_}Systems{_}Based{_}on{_}Glinks/5bdccf17a6fdcc3a8db9bfb7/Gamif>. Citation on page 24.

SCHELL, J. **The Art of Game Design: A Book of Lenses, Second Edition**. CRC Press, 2014. 600 p. ISBN 1466598646. Available: <https://books.google.com/books?id=kRMeBQAAQBAJ{&}pgis=1>. Citation on page 23.

SEABORN, K.; FELS, D. I. Gamification in Theory and Action: A Survey. **Internatoinal Journal of Human-Computer Studies**, v. 74, p. 14–31, 2014. ISSN 10959300. Citations on pages 23, 24, 25, 27, 31, and 34.

SHELDON, L. **The Multiplayer Classroom: Designing Coursework as a Game**. Cengage Learning, 2011. 304 p. ISBN 1435458451. Available: <https://books.google.com/books?id=qYMLAAAAQBAJ{&}pgis=1>. Citation on page 23.

SMITH-ROBBINS, S. This Game Sucks: How to Improve the Gamification of Education. **Educause Review**, v. 46, n. 1, p. 58 – 59, 2011. ISSN 15276619. Available: <http://www.educause.edu/EDUCAUSE+Review/EDUCAUSEReviewMagazineVolume46/ThisGameSucksHowtoImprovetheGa/222665>. Citation on page 25.

TODA, A.; KLOCK, A. C. T.; PALOMINO, P. T.; RODRIGUES, L.; OLIVEIRA, W.; STEWART, C.; CRISTEA, A. I.; GASPARINI, I.; ISOTANI, S. GamiCSM: Relating education, culture and gamification - a link between worlds. In: **XIX Brazilian Symposium on Human Factors in Computing Systems**. Diamantina: [s.n.], 2020. p. In press. Citations on pages 15, 39, 40, and 62.

TODA, A.; PALOMINO, P. T.; RODRIGUES, L.; OLIVEIRA, W.; SHI, L.; ISOTANI, S.; CRISTEA, A. I. Validating the Effectiveness of Data-Driven Gamification Recommendations: An Exploratory Study. In: **Proceedings of the SBIE 2019**. Brasilia: Brazilian Computer Society (Sociedade Brasileira de Computação - SBC), 2019. v. 30, n. November, p. 763 – 772. ISSN 2316-6533. Available: <https://br-ie.org/pub/index.php/sbie/article/view/8804>. Citations on pages 15, 28, 53, 54, and 56.

TODA, A.; PEREIRA, F. D.; KLOCK, A. C. T.; RODRIGUES, L.; PALOMINO, P.; OLIVEIRA, W.; OLIVEIRA, E. H. T.; GASPARINI, I.; CRISTEA, A. I.; ISOTANI, S. For whom should we gamify? Insights on the users intentions and context towards gamification in education. n. Cbie, p. 471–480, 2020. Citations on pages 28, 54, and 56.

TODA, A.; SILVA, Y.; CRUZ, W.; XAVIER, L.; ISOTANI, S.; RAFAEL, Y.; CRUZ, W.; XAVIER, L.; ISOTANI, S. Um processo de Gamificação para o ensino superior: Experiências em um módulo de Bioquímica. In: **Anais do Workshop de Informática na Escola**. [s.n.], 2016. v. 22, n. 1, p. 495. ISSN 2316-6541. Available: <http://www.br-ie.org/pub/index.php/wie/article/view/6856>. Citations on pages 26, 27, 44, and 45.

TODA, A. M.; CARMO, R. M. do; SILVA, A. P. da; BITTENCOURT, I. I.; ISOTANI, S. An approach for planning and deploying gamification concepts with social networks within educational contexts. **International Journal of Information Management**, Pergamon, oct 2018. ISSN 0268-4012. Available: <https://www.sciencedirect.com/science/article/pii/S0268401218304614>. Citations on pages 15, 26, 27, 34, 45, 46, and 49.

TODA, A. M.; CARMO, R. M. do; SILVA, A. P. da; ISOTANI, S. GAMIFY-SN: A meta-model for planning and deploying gamification concepts within social networks - A case study. In: **Advances in Intelligent Systems and Computing**. Pergamon, 2018. v. 746, p. 1357–1366. ISBN 9783319777115. ISSN 21945357. Available: <http://link.springer.com/10.1007/978-3-319-77712-2{_}130https://www.sciencedirect.com/science/article/pii/S0268401218304614>. Citation on page 27.

TODA, A. M.; ISOTANI, S. Um processo para geração de designs gamificados para o ensino. In: **I Workshop de Educação Digital e Interativa (WEDI)**. [S.l.: s.n.], 2016. Citations on pages 27, 43, and 44.

TODA, A. M.; KLOCK, A. C. T.; OLIVEIRA, W.; PALOMINO, P. T.; RODRIGUES, L. L.; SHI, L.; BITTENCOURT, I.; GASPARINI, I.; ISOTANI, S.; CRISTEA, A. I. Analysing gamification elements in educational environments – Using an existing Gamification Taxonomy. **Smart Learning Environments**, Springer Singapore, v. 6, n. 1, p. 16, dec 2019. ISSN 2196-7091. Available: <https://slejournal.springeropen.com/articles/10.1186/s40561-019-0106-1>. Citations on pages 15, 26, 27, 46, 47, and 48.

TODA, A. M.; OLIVEIRA, W.; KLOCK, A. C.; PALOMINO, P. T.; PIMENTA, M.; GASPARINI, I.; SHI, L.; BITTENCOURT, I.; ISOTANI, S.; CRISTEA, A. I.; SHI, L.; GASPARINI, I.; ISOTANI, S.; CRISTEA, A. I. A Taxonomy of Game Elements for Gamification in Educational Contexts: Proposal and Evaluation. In: **IEEE 19th International Conference on Advanced Learning Technologies (ICALT)**. [S.l.: s.n.], 2019. p. 84–88. Citations on pages 15, 17, 25, 34, 35, 36, 37, 38, 39, 44, 46, and 48.

TODA, A. M.; OLIVEIRA, W.; SHI, L.; BITTENCOURT, I.; ISOTANI, S.; CRISTEA, A. Planning Gamification Strategies based on User Characteristics and DM : A Gender-based Case Study. In: **Proceedings of the Educational Data Mining 2019 conference**. Montréal: [s.n.], 2019. p. 438 – 443. Available: <http://arxiv.org/abs/1905.09146>. Citations on pages 15, 28, 34, 49, 51, 52, 53, 54, and 56.

TODA, A. M.; PALOMINO, P. T.; OLIVEIRA, W.; RODRIGUES, L.; KLOCK, A. C. T.; GASPARINI, I.; CRISTEA, A. I.; ISOTANI, S. How to Gamify Learning Systems? An Experience Report using the Design Sprint Method and a Taxonomy for Gamification Elements in Education. **Journal of Educational Technology & Society**, JSTOR, v. 22, n. 3, p. 47–60, 2019. Citations on pages 26, 27, and 48.

TODA, A. M.; SANTOS, W. O. dos; KLOCK, A. C. T.; GASPARINI, I.; BITTENCOURT, I. I.; ISOTANI, S. Frameworks para o Planejamento da Gamificação em Contextos Educacionais - Uma revisão da literatura nacional. **RENOTE**, v. 16, n. 2, dec 2018. ISSN 1679-1916. Available: <https://www.seer.ufrgs.br/renote/article/view/89240>. Citations on pages 15, 25, 26, 34, and 35.

TODA, A. M.; TODA, A. M.; SILVA, A. P. da; ISOTANI, S. Desafios para o Planejamento e Implantação da Gamificação no Contexto Educacional. **RENOTE**, v. 15, n. 2, jan 2017. ISSN 1679-1916. Available: <http://seer.ufrgs.br/index.php/renote/article/view/79263>. Citations on pages 15, 25, 33, 34, and 36.

TODA, A. M.; VALLE, P. H. D.; ISOTANI, S. The Dark Side of Gamification: An Overview of Negative Effects of Gamification in Education. In: **Communications in Computer and Information Science**. Springer, Cham, 2018. v. 832, p. 143–156. ISBN 9783319979335. ISSN 18650929. Available: <http://link.springer.com/10.1007/978-3-319-97934-2{_}9>. Citations on pages 15, 25, 26, 31, and 32.

WERBACH, K.; HUNTER, D. **For the Win: How Game Thinking Can Revolutionize Your Business**. Wharton Digital Press, 2012. 144 p. ISBN 1613630239. Available: <https://books.google.com/books?id=abg0SnK3XdMC{&}pgis=1>. Citation on page 26.

ZICHERMANN, G.; CUNNINGHAM, C. **Gamification by Design: Implementing Game Mechanics in Web and Mobile Apps**. O'Reilly Media; 1 edition, 2011. 208 p. ISBN 1449397670. Available: <http://www.amazon.com/Gamification-Design-Implementing-Mechanics-Mobile/dp/1449397670/ref=sr{_}1{_}8?ie=UTF8{&}qid=1395318226{&}sr=8-8{&}keywords=gamification>. Citation on page 24.

ANNEX

A

THE DARK SIDE OF GAMIFICATION: AN OVERVIEW OF NEGATIVE EFFECTS OF GAMIFICATION IN EDUCATION

The dark side of gamification: An overview of negative effects of gamification in education

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Abstract. Gamification has a great number of studies in education area since the emergence of the term. However, there is a lack of primary and secondary studies that explores the negative effects that gamification may have on learners, and lack of studies that analyze the gamified design that are linked to those negative effects. Based on this premise, we aim at answering the following research question "What are the negative effects that can occur in gamification when applied to educational contexts?". We seek to answer this question by analyzing the negative effects that are associated to gamification and the gamified learning design that are linked with them. To answer this question, we conducted a systematic mapping study to identify these negative effects. Based on the studies that were analyzed, we identified and mapped 4 negative effects and their gameful design. Loss of Performance was the most occurring effect and Leaderboard the most cited game design element, among other 11 elements. Moreover, elements and effects were linked in order to identify how these elements may have influenced on these outcomes. Based on our results, we found that the game design may lead to a negative impact. For instance, Leaderboards are strongly associated to many negative effects mapped in this work. This result is corroborated by the psychology literature regarding ranking systems within learning environments. We believe our work may be useful to guide gamification instructors and specialists to avoid those negative effects in education contexts, by avoiding some game design elements settings.

Keywords: gamification, systematic mapping, negative effects, education

1 Introduction

Gamification has been widely explored in the past 7 years since the term was conceptualized by Deterding (2011)[13], as the use of game elements outside their scope. Since then, gamification studies have covered many areas, ranging

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from Economy to Education. However, most of gamification studies focus on the educational context [11], where researchers aim those game elements to improve learning efficiency and learner's motivation [18]. Most of gamification studies in education have focused on exploring the positive motivational achievements, however there is still a gap regarding the identification of negative outcomes on students [14, 6].

It is also well known that gamification is context-dependent, and inserting game elements such as Points, Badges and Leaderboards (PBL Approach), without proper design, will not ensure the positive desired outcomes [5]. Gamification experts are already concerned about individual and collective variables, such as profiling users, in order to recommend a well-thought gamified scenario. Therefore, there is still a lack of studies that address or are concerned with the potential negative effects caused by gamification on learners in the educational context [19]. Thiebes et al (2014) [33] present a list of issues that should be addressed by specialists when designing a gamified task or system, which are: Declining Effects, Cheating the System, Privacy and Task Quality. However, those issues are related to online gamified environments, and not specifically to educational contexts. Kim & Werbach (2016) [19] debate some ethical issues related to gamification, such as Exploitation and Manipulation, presenting a framework on how to avoid them, again these issues are not related to education or learners. Finally, Andrade et al (2016) [1] discuss some negative effects of gamification, such as lack of attention, in the Intelligent Tutoring Systems area. Other gamification studies also imply a set of properties that need to be addressed in the design of gamification in order to deploy it, especially regarding the Education area, such as learners' genres and player profiles [4, 28].

In this context, this study aims at answering the following question: "What are the negative effects that can occur in gamification when applied to educational contexts?". To answer our research question, we performed a systematic mapping study, based on Kitchenham (2004) [20] guidelines, aiming at classifying the negative outcomes and identifying the gamified designs, in this study we consider a gamified design as a set of strategies using game elements to perform a task. To present our research, this paper is organized as follows: Section 2 presents the related works, Section 3 presents the protocol. Section 4 presents the results and, finally, Section 5 presents the conclusions, discussions and future work.

2 Related Work

Gamification secondary studies have increased drastically in the past 10 years. Some of them, as the work performed by Borges et al (2014) and Dicheva et al (2015) [6, 14], focus on associating the good impact of gamification elements (considering their properties and rules) in educational contexts, in which most of the analyzed studies have achieved positive outcomes, dealing with users' behavior, and increasing their motivation. These authors also present a gap regarding the lack of empirical studies to attest the positive effects of gamification, and also

do not address possible negative outcomes related to gamification bad design in education domain.

Another relevant study is conducted by Thiebes et al (2014) [33], which focus at identifying which game elements were used in the field of Information Systems. The authors propose a list issues that can be influenced by gamification bad design, however the authors states that these are exclusive to online environments with gamified tasks.

Markopoulos et al (2015) [22] also conducted a literature overview of gamification in education domain, presenting a list of critic points which correspond to extrinsic rewards that, when badly designed in gamified applications, can decrease learners' intrinsic motivation. The authors also claim that gamification may not be well accepted by teachers and instructors and that it can be difficult to obtain a balanced gamified scenario. Finally, they claim that gamification may not be applicable to every learning context.

In other domains, the positive effects of gamification are also not validated. According to Pedreira et al (2015) [27] in their systematic mapping on gamification applied to Software Engineering, there is still a lack of empirical studies to attest the effects promoted by gamification. Furthermore, an analysis of those effects and how to design their gamified strategies is needed. This statement is reinforced by Sigala (2015) [30], where the author present a literature overview regarding gamification in Marketing, Tourism and Crowdsourcing. According to the author, gamification may "wear out" in a scenario in which gamified design has not been considered.

These studies allow us to observe a gap, in the sense that (i) negative outcomes of gamification are known but not properly mapped and (ii) there is a lack of information regarding negative effects and the gamified design that is used. Based on this gap, the next sections present the mapping of the negative effects associated with gamification in educational contexts, along with their gamified designs.

3 Protocol

The focus of this systematic mapping is to answer our main question "What are the negative effects that can occur in gamification when applied to educational contexts?" by identifying the main negative effects caused by gamification on learners. In order to conduct this study, we used the online tool Parsif.al and Google Docs to organize the mapping, as well as the guidelines proposed by Kitchenham (2004)[20], which consist of 3 steps: (i) planning, where we define our research questions, Inclusion and Exclusion Criteria and other definitions related to the mapping; (ii) conduction, where we conduct our research in the selected databases, select the papers and perform the data extraction; and (iii) results, where we summarize the data and evaluate the results. Based on these guidelines, we defined 2 research questions to guide this study:

RQ1 - What are the negative outcomes related to gamification in Education?

This question focus on identifying what are the main issues related to gamification applied to Education. By identifying those issues, we can encourage future studies on how to avoid them. Furthermore, the literature lacks formal classification of those issues regarding the educational context.

RQ2 - How is the gamified design related to these outcomes?

This question aims at associating the negative effects with the respective gamified designs, in order to identify which game elements and rules are linked to those effects. By identifying the gamification setup, we aim at encouraging future studies to carefully choose which and how those game elements may impact students' perception on gamification in the context of Education.

In order to answer those research questions, we defined 3 main terms to create the research string: Gamification, Education and Negative Effects. Some negative effects were previously collected based on 6 control papers that we used to aid in the string creation, which are: *gamification AND (failure OR problem OR privacy OR declining effect OR cheating the system OR exploit OR bad OR addiction) AND (education OR learning OR training OR instruction)*. This string returned all of the 6 control papers in one or more research bases.

As for the research bases, we choose the ones that are used and cited in Computer Science domain and were used in other secondary studies, as: ACM Digital Library, AISEL, IEEE Xplore, ISI Web of Science, ScienceDirect, Scopus and Wiley Online Library. As for the Selection Criteria, we defined 4 Inclusion and 6 Exclusion Criteria. In our Inclusion Criteria (IC), we defined that (a) studies should have been published in the past 7 years; (b) studies should be in the English language; (c) studies should contain explicit evidence(s) regarding a negative effect associated with gamification; and (d) studies should be full papers published in a conference, journal or book chapter. As for our Exclusion Criteria (EC), we excluded (a) studies focused on serious games; (b) studies that were short papers, position papers or panels; (c) studies that contained risks associated with different areas from Education; (d) studies that did not contain any explicit negative effect associated with gamification; and (e) secondary studies.

Through the adequacy of the string to each of the databases, we began the searches in June, 2016. Our search returned a total of 1328 papers, that were screened by title, abstract and keywords. After this step, we obtained a set of candidate studies (c = 220 papers) that would be filtered by our Inclusion and Exclusion Criteria. After the application of the criteria and the deletion of duplicate papers, we obtained the final set of studies (n = 17 papers) that would be analyzed and discussed in this work. We also included 3 studies that were not returned by our search string, but were cited in other papers. The number of studies and the complete list of analyzed papers can be seen on <`https://goo.gl/3qrKv7`>.

After the final selection, we began the Data Extraction phase, in which we mapped the negative effects into the gamified design that were used in the studies. These negative effects were based on their occurrence in the papers, by checking the exact words or the general meaning when analyzing the results of the primary studies.

4 Results and Discussions

This section presents the answers for our research questions based on our protocol. In Figure 1, we analyze the areas of the selected studies. From this figure, we observe that most of the studies are in the field of Computer Science — specifically 10 studies. However, we also found studies in Administration, Communication, Mathematics, High School, Engineering and Arts.

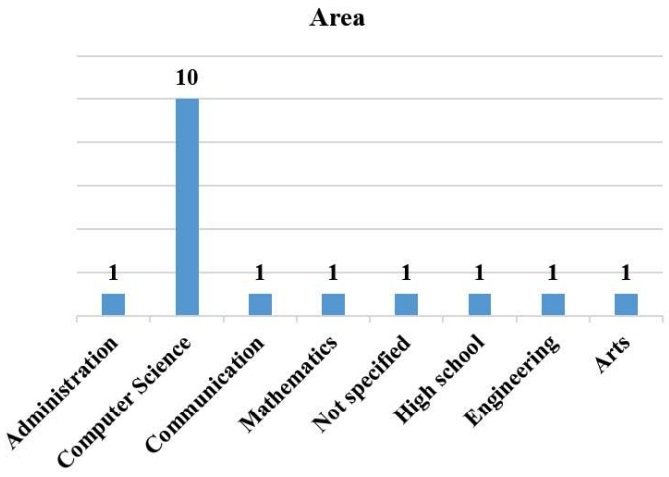

Fig. 1. Studies per Area

We also analyzed the type of publication of the studies. From Figure 2, we can observe that 10 studies were published in Symposiums/Conferences, 6 studies were published in Journals and only 1 study was published in a Workshop.

The selected studies are considered recent, once that all of them were published in the last 5 years. This behavior was already expected, since gamification is considered a recent area of research. In Figure 3, we can observe the distribution of the studies per year of publication. Most of the analyzed studies were published between 2014 and 2015.

We also analyzed the country of origin regarding the first author of each study, to verify which countries and research groups have been conducting research on the topic of this systematic mapping. We observed that most of the research has been carried out by researchers from the United States and Germany, as presented in Figure 4.

Furthermore, by analyzing the focus of the studies, we identified 3 main ones: tool, where the authors described a technology to deploy the gamification; evidence, where the focus of the study was to give evidence regarding gamification properties; and method, where the authors focused on describing a method or

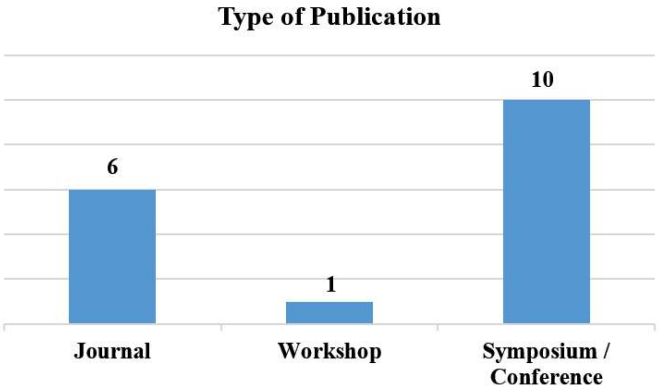

Fig. 2. Studies per type of publication

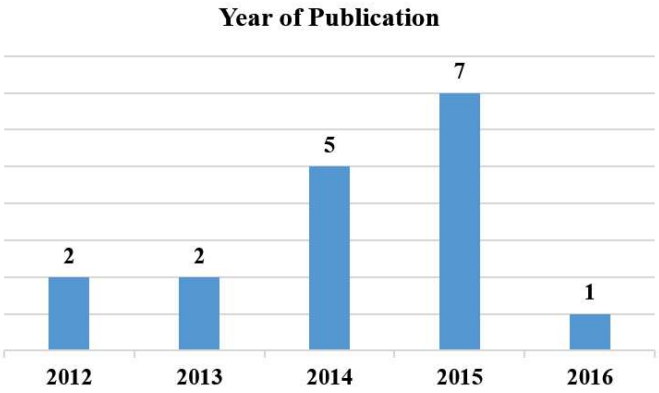

Fig. 3. Studies per year of publication

process. The distribution of studies per focus is shown in Figure 5. We observed that most studies focused on tools, specifically 9 of them.

Finally, regarding the outcomes of each analyzed study, we observed that 6 studies had positive results, 2 studies had negative results and 9 studies had mixed results, as presented in Figure 6. This classification was based on the outcomes reported by the authors of the selected studies.

4.1 3.1 What are the negative outcomes related to gamification in Education?

Based on the outcomes and reports in the studies, we identified 4 negative effects: Indifference, Loss of performance, Undesired behavior and Declining effects. Those effects and their references can be seen on Table 1 below.

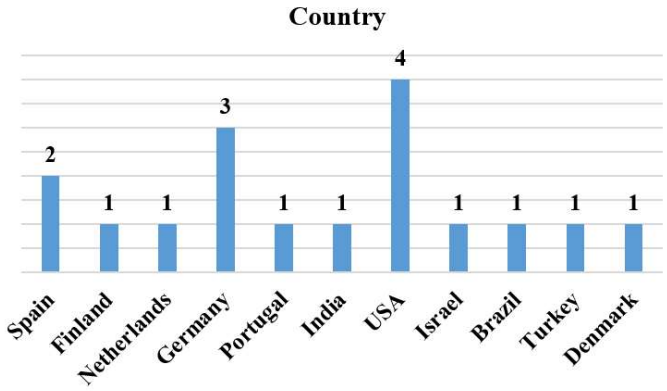

Fig. 4. Studies per country

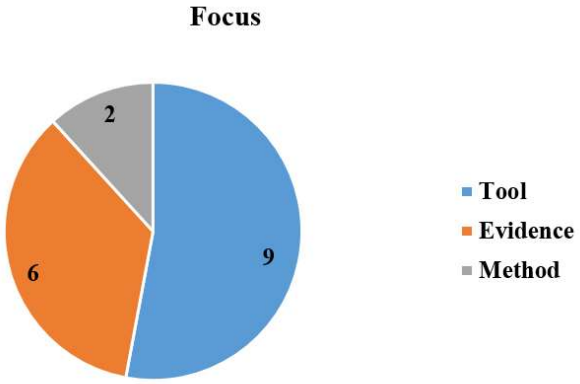

Fig. 5. Focus of the studies

Loss of Performance was the most reported issue, identified in 12 studies. This issue arise from tasks and situations where gamification harms or hinders students' learning process. Most of those studies reported mixed outcomes, with positive and negative results after applying gamification in their learning contexts. Marcos et al (2014) reported that gamification may be related to loss of performance in the case of some students, and a similar scenario is seen in the study performed by Naik & Kamat (2015)[25]. Barata et al (2014)[3], Attali & Ariev-Attali (2015)[2] and Hanus & Fox (2014)[17] stated that gamification had an influence on learners' loss of performance during the study due to demotivating effects. Campos et al (2015)[8] reported that some learners did not understand the rules and this may have hindered their performance. There is a similar report made by Prause & Jarke (2015)[29], but in this study learners

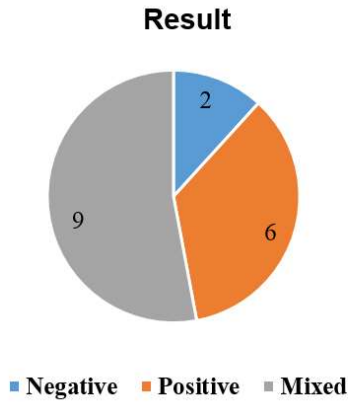

Fig. 6. Reported results of the studies

did not like being penalized in the gamified activity. Snow et al (2015) reported that students that were more active in the gamified activity scored lower than their peers in the transfer skill tests. Kocadere & Çağlar (2015)[21] found similar results, as their learners were more focused on the gamified mechanics than on the assessment. Finally, McDaniels, Lindgren & Friskics (2012)[23] stated that students felt that the gamified activities were too difficult, which also impacted their grades.

Undesired Behavior was the second most cited issue, presented in 9 studies. This occurred because gamification caused a different effect (positive or negative) on the learning context in which it was applied, either due to bad planning or to the lack of it. Haaranen et al (2014) mentioned that the number of tasks declined in the gamified environment, which was the opposite of what the authors expected. Singer & Schneider (2012)[31] reported that some students stated that the bonus system were not satisfying, and they did not receive most of the gamified notifications due to problems in the system. The gamified application of Domínguez et al (2013)[15] was not well received by learners, who stated that the system was not enjoyable and that it was a waste of time. Codish & Ravid (2014)[10] stated that their mechanics caused demotivation due to excessive competition, which was also reported in the studies of Campos et al (2015)[8], Prause & Jarke (2015)[29] and Papadopoulos, Lagkas & Demetriadis (2016)[26], since they employed similar mechanics. Snow et al (2015)[26] stated that learners were more focused on the gamification mechanics than on the learning assessment itself, when they should have done the opposite. Finally, McDaniels, Lindgren & Friskics (2012)[23] reported that the students became frustrated for not completing the badges, also stating that the activities were too difficult.

Following Undesired Behavior is Indifference. This occurs when gamification is reported to not have influenced, either for the better or for the worse, the

Table 1. Negative effects and their studies

Effect	**Frequency**	**References**
Indifference	6	(Marcos et al, 2014)[12], (Haaranen et al, 2014)[16], (Buisman & van Eekelen, 2014)[7], (Berkling & Thomas, 2013)[4], (Domínguez et al, 2013)[15], (Papadopoulos, Lagkas & Demetriadis, 2016)[26]
Loss of Performance	12	(Marcos et al, 2014)[12], (Haaranen et al, 2014)[16], (Barata et al, 2014)[3], (Berkling & Thomas, 2013)[4], (Naik & Kamat, 2015)[25], (Hanus & Fox, 2014)[17], (Attali & Ariev-Attali, 2015)[2], (Campos et al, 2015)[8], (Prause & Jarke, 2015)[29], (Kocadere & Çağlar, 2015)[21], (Snow et al, 2015)[32], (McDaniels, Lindgren & Friskics, 2012)[23]
Undesired Behavior	9	(Haaranen et al, 2014)[16], (Singer & Schneider, 2012)[31], (Domínguez et al, 2013)[15], (Codish & Ravid, 2014)[10], (Campos et al, 2015)[8], (Prause & Jarke, 2015)[29], (Snow et al, 2015)[32], (Papadopoulos, Lagkas & Demetriadis, 2016)[26], (McDaniels, Lindgren & Friskics, 2012)[23]
Declining Effects	5	(Berkling & Thomas, 2013)[4], (Hanus & Fox, 2014)[17], (Domínguez et al, 2013)[15], (Campos et al, 2015)[8], (Attali & Ariev-Attali, 2015)[2]

learners within the study. Marcos et al (2014) reported that, overall, gamification did not improve learners' gain of knowledge compared to the traditional learning method. A similar thought is shared by the studies of Domínguez et al (2013)[15] and Papadopoulos, Lagkas & Demetriadis (2016)[26], in which gamification did not exert any impact on cognition and performance. Haaranen et al (2014)[16] stated that learners felt indifferent towards the gamified application, which for them was neither enjoyable nor boring. Buisman & van Eekelen (2013)[7] reported in their study that gamification did not impacted learners' motivation and engagement. Finally, Berkling & Thomas (2013)[4] also reported that some students were not interested in the gamification that was implemented, choosing traditional methods over gamified ones.

Finally, Declining Effects are related to the gradual loss of motivation and engagement due to the gamification that was deployed. This issue was found in 5 studies and, despite being similar to Loss of Performance from the viewpoint that learners' progress is hindered in both scenarios, it differs from Loss of Performance in the sense that learners' motivation and engagement decrease over time, which also may lead to Loss of Performance. Berkling & Thomas (2013) [4] stated that a group of students lost interest in the gamification over time as they used the system. Hanus & Fox (2015) [17] and Attali & Ariev-Attali (2015)

[2] reported similar results, adding a gradual loss of motivation. Finally, Campos et al (2015) [8] stated that students felt demotivated for not understanding the rules. Moreover, they became reluctant in the end of the study to use the gamified assessment, thinking that it could affect their grades.

Based on our findings from these studies, it is clear that those issues occurred due to the lack of proper methods and/or frameworks for planning and deploying gamification in a learning context. Another issue that influenced on those outcomes is the absence of instructional theories to support the implantation of gamification, especially motivational design theories, since most of the studies focused on increasing learners' motivation and engagement. These instructional design theories are needed to produce well-thought gamified strategies that will have positive impacts on the students. This statement is also corroborated by Attali & Arieli-Attali (2015) [2] and Marcos et al (2014) [12].

4.2 How is the gamified design related to these outcomes?

From the pool of selected papers, we were able to identify and classify 12 game elements that had been deployed: Leaderboard, Badge, Point, Level, Progression, Social Status, Social Interaction, Instant Feedback, Avatar, Economy, Challenge and Narrative. We used the definitions regarding game elements based on the work of Dicheva et al (2015) [14] and Thiebes et al (2014) [33]. Other elements that were found were incorporated into the set of 12 elements due to similar semantics and different syntaxes. The distribution of elements per study can be seen in Table 2.

Table 2. Game elements and their frequency in the poll of studies

Game element	**Frequency**	**Studies**
Leaderboard	14	[12] [7] [31] [3] [4] [25] [17] [15] [10] [8] [29] [21] [26] [23]
Badge	13	[12] [16] [31] [3] [4] [25] [17] [15] [10] [8] [21] [32] [23]
Point	12	[16] [7] [3] [4] [25] [2] [10] [8] [29] [21] [32] [23]
Level	9	[12] [3] [4] [25] [2] [10] [29] [21] [32]
Progression	4	[12] [4] [25] [10]
Social Status	4	[12] [3] [4] [29]
Social Interaction	2	[31] [29]
Instant Feedback	3	[4] [21] [32]
Avatar	3	[3] [21] [32]
Economy	1	[32]
Challenge	1	[4]
Narrative	1	[23]

Table 2 demonstrates a concentration on the PBL (Point-Badge-Leaderboard) approach, deployed by more than 10 studies. This may have impacted on most of the issues, since the PBL approach may not be suitable for certain situations and contexts [5]. This is especially the case when applying a gamification design template without considering individual profiles, instructional and motivational design theories. Next, we identified which elements were related to - and which ones impacted - the aforementioned negative effects. The results can be seen on Table 3. It is possible to observe that Leaderboard had a strong influence on almost all of the negative effects, followed by Point and Badge, both with the same influence.

Table 3. Negative effects and their respective gamified designs

Negative Effect	**# of Elements**	**Elements**	**Most Impacting Element**
Indifference	8	Leaderboard, Badge, Level, Progression, Social Status, Point, Instant Feedback, Challenge	Leaderboard and Badge
Loss of Performance	11	Leaderboard, Badge, Level, Social Status, Social Interaction, Point, Avatar, Progression, Instant Feedback, Challenge, Economy	Leaderboard, Badge and Point
Undesired Behavior	11	Leaderboard, Badge, Point, Level, Instant Feedback, Progression, Social Status, Social Interaction, Avatar, Economy, Narrative	Badge and Leaderboard
Declining Effects	4	Leaderboard, Badge, Point, Level	Leaderboard and Point

Based on the mapping of the game elements into each negative effect in Table 3, we cannot affirm that these elements exert a highly influence in causing these negative effects, but we believe that these findings demonstrate the necessity of studying those elements individually, in order to confirm that. However, this study allows us to state that deploying the PBL approach without proper instructional and motivational design support may lead to those negative effects. Proposals on this topic can be seen in the initial work of Toda et al (2016) [24], in which the authors developed a metaprocess aiming at aligning lesson plans with gamification strategies in classroom scenarios, and in the work of Chalco et al (2016) [9], which proposes the use of ontologies to build proper gamified strategies in the context of Computer-Supported Collaborative Learning.

5 Conclusions, Limitations and Future Works

We proposed in this study a systematic mapping on the negative effects associated with gamification in educational contexts, and aimed at understanding the

relation among them. We believe that we were able to answer our research questions, as well as providing some advances to the existing literature by making an initial systematic classification of those negative effects in the context of Education. We also believe that this study may provide guidance to avoid undesired outcomes when applying gamification in educational scenarios, it corroborates the existing literature on the need of systematic methods and approaches that align instructional and motivational design theories with gamification-related objectives and strategies. Another important artifact from this study is the analysis between the negative effects and the main game elements that were used, which reinforces the idea that the PBL approach may cause various problems if not well designed or supported by instructional and motivational design theories.

This study, however, present some limitations, one of them being the time frame in which the research was conducted, which excluded papers from the second semester of 2016. We also did not consider gray literature which might contain other significant results, nor papers from other languages rather than english.

In future work, we intend to carry out a deeper analysis of those primary studies, aiming at identifying their objectives and statistically analyzing how those negative effects influence each other. Individual analyses of each game element in the respective gamified designs are also in progress. Finally, we also intend to propose an approach to guide gamification experiments in order to avoid those negative outcomes, by means of a systematic process and ontological support.

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References

1. Andrade, F.R.H., Mizoguchi, R., Isotani, S.: The bright and dark sides of gamification. In: Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics). pp. 176–186 Springer-Verlag New York, Inc. (2016).
2. Attali, Y., Arieli-Attali, M.: Gamification in assessment: Do points affect test performance? Comput. Educ. 83, 57–63 (2015).
3. Barata, G., Gama, S., Jorge, J., Gonçalves, D.: Improving participation and learning with gamification. In: Proceedings of the First International Conference on Gameful Design, Research, and Applications - Gamification '13. pp. 10–17 ACM Press, New York, New York, USA (2013).
4. Berkling, K., Thomas, C.: Gamification of a Software Engineering course and a detailed analysis of the factors that lead to it's failure. Interact. Collab. Learn. (ICL), 2013 Int. Conf. September, 525–530 (2013).
5. Bogost, I.: Gamification is Bullshit. In: The Gameful World. The MIT Press (2014).

6. Borges, S. de S., Durelli, V., Reis, H., Isotani, S.: A systematic mapping on gamification applied to education. In: Proceedings of the 29th Annual ACM Symposium on Applied Computing - SAC '14. pp. 216–222 (2014).
7. Buisman, A.L.D., van Eekelen, M.C.J.D.: Gamification in educational software development. Proc. Comput. Sci. Educ. Res. Conf. - CSERC '14. VV, 9–20 (2014).
8. Campos, A., Batista, E., Signoretti, A., Gardiman, R., Madeira, C.: Gamifying activities in a higher education course. Proc. Eur. Conf. Games-based Learn. 2015–Janua, October 2015, 117–124 (2015).
9. Challco, G.C., Mizoguchi, R., Isotani, S.: An Ontology Framework to Apply Gamification in CSCL Scenarios as Persuasive Technology. Rev. Bras. Informática na Educ. XX, 2, 67 (2016).
10. Codish, D., Ravid, G.: Personality Based Gamification: How Differente Personalities Perceive Gamification. Proc. 22nd Eur. Conf. Inf. Syst. 11 (2012).
11. Darejeh, A., Salim, S.S.: Gamification Solutions to Enhance Software User Engagement – A Systematic Review. Int. J. Hum. Comput. Interact. 7318, May, 10447318.2016.1183330 (2016).
12. De-Marcos, L., Domínguez, A., Saenz-de-Navarrete, J., Pagés, C.: An empirical study comparing gamification and social networking on e-learning. Comput. Educ. 75, 82–91 (2014).
13. Deterding, S., Sicart, M., Nacke, L., O'Hara, K., Dixon, D.: From Game Design Elements to Gamefulness: Defining "Gamification." Proc. 2011 Annu. Conf. Ext. Abstr. Hum. factors Comput. Syst. - CHI EA '11. 2425 (2011).
14. Dicheva, D., Dichev, C.: Gamification in Education: Where Are We in 2015? E-Learn 2015 - Kona, Hawaii, United States. July 2014, 1445–1454 (2015).
15. Domínguez, A., Saenz-de-Navarrete, J., De-Marcos, L., Fernández-Sanz, L., Pagés, C., Martínez-Herráiz, J.: Gamifying learning experiences: Practical implications and outcomes. Comput. Educ. 63, null, 380–392 (2013).
16. Haaranen, L., Ihantola, P., Hakulinen, L., Korhonen, A.: How (not) to introduce badges to online exercises. Proc. 45th ACM Tech. Symp. Comput. Sci. Educ. - SIGCSE '14. 33–38 (2014).
17. Hanus, M.D., Fox, J.: Assessing the effects of gamification in the classroom: A longitudinal study on intrinsic motivation, social comparison, satisfaction, effort, and academic performance. Comput. Educ. 80, 152–161 (2014).
18. Kapp, K.M.: The Gamification of Learning and Instruction: Game-based Methods and Strategies for Training and Education. (2012).
19. Kim, T.W., Werbach, K.: More than just a game: ethical issues in gamification. Ethics Inf. Technol. 18, 2, 157–173 (2016).
20. Kitchenham, B.: Procedures for Performing Systematic Reviews. (2004).
21. Kocadere, S.A., Çağlar, Ş.: The design and implementation of a gamified assessment. J. E-Learning Knowl. Soc. 11, 3, 85–99 (2015).
22. Markopoulos, A.P., Fragkou, A., Kasidiaris, P.D., Davim, J.P.: Gamification in engineering education and professional training. Int. J. Mech. Eng. Educ. 43, 2, 118–131 (2015).
23. McDaniel, R., Lindgren, R., Friskics, J.: Using badges for shaping interactions in online learning environments. IEEE Int. Prof. Commun. Conf. 12–15 (2012).
24. Toda, A., Silva, Y.R., Cruz, W., Xavier, L., Isotani, S.: Um processo de Gamificação para o ensino superior: Experiências em um módulo de Bioquímica. In: Anais do Workshop de Informática na Escola. p. 495 (2016).
25. Naik, V., Kamat, V.: Adaptive and Gamified Learning Environment (AGLE). In: Proceedings - IEEE 7th International Conference on Technology for Education, T4E 2015. pp. 7–14 IEEE (2016).

26. Papadopoulos, P.M., Lagkas, T., Demetriadis, S.N.: How revealing rankings affects student attitude and performance in a peer review learning environment. In: Communications in Computer and Information Science. pp. 225–240 Springer International Publishing (2016).
27. Pedreira, O., García, F., Brisaboa, N., Piattini, M.: Gamification in software engineering - A systematic mapping. Inf. Softw. Technol. 57, 1, 157–168 (2015).
28. Pedro, L.Z., Lopes, A.M.Z., Prates, B., Vassileva, J., Isotani, S.: Does gamification work for boys and girls? Proc. 30th Annu. ACM Symp. Appl. Comput. - SAC '15. 214–219 (2015).
29. Prause, C.R., Jarke, M.: Gamification for enforcing coding conventions. In: Proceedings of the 2015 10th Joint Meeting on Foundations of Software Engineering - ESEC/FSE 2015. pp. 649–660 ACM Press, New York, New York, USA (2015).
30. Sigala, M.: Gamification for Crowdsourcing Marketing Practices: Applications and Benefits in Tourism. In: Advances in Crowdsourcing. pp. 129–145 Springer International Publishing, Cham (2015).
31. Singer, L., Schneider, K.: It was a bit of a race: Gamification of version control. Games Softw. Eng. (.... 5–8 (2012).
32. Snow, E.L., Allen, L.K., Jackson, G.T., McNamara, D.S.: Spendency: Students' Propensity to Use System Currency. Int. J. Artif. Intell. Educ. 25, 3, 407–427 (2015).
33. Thiebes, S., Lins, S., Basten, D.: Gamifying information systems A synthesis of gamification mechanics and dynamics. Twenty Second Eur. Conf. Inf. Syst. 1–17 (2014).

ANNEX

B

CHALLENGES FOR PLANNING GAMIFICATION IN EDUCATIONAL CONTEXT - IN BRAZILIAN PORTUGUESE

Desafios para o Planejamento e Implantação da Gamificação no Contexto Educacional

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Resumo:
A gamificação vem sendo difundida no contexto educacional como uma forma de aprimorar o engajamento e a motivação de alunos. Vários estudos mostram os resultados positivos de sua aplicação, o que faz com que as pesquisas nessa área estejam ganhando espaço na ciência. No entanto, para alcançar estes resultados, é necessário realizar um bom planejamento do contexto que está sendo sendo submetido para gamificação. Até o momento não há estudos que reportem problemas que podem ocorrer em contextos educacionais durante a fase de planejamento, a fim de evitá-los. Por conta disto, este trabalho propõe uma análise de estudos secundários (revisões sistemáticas e da literatura), visando a identificação destes problemas referentes às fases de planejamento e implantação da gamificação. No total, foram analisados onze trabalhos e identificados seis problemas relacionados ao design da gamificação. A partir da identificação desses obstáculos, este trabalho fornece uma base para que futuras abordagens de gamificação possam evitá-los durante o planejamento e implantação.
Palavras-chaves: gamificação, revisão sistemática, design

Abstract:
Gamification has been widely widespread in educational context as a way to improve students' engagement and motivation. Many studies demonstrate the positive effects of its applications, which increases its popularity among scientific area. However, in order to achieve these positive results, it is necessary to perform a good planning of what contexts are intended to gamify. Until now, there is a lack of studies that report the problems that can occur in educational contexts during planning and implanting phase of gamification, in order to avoid them. Therefore, this work propose an analysis of secondary studies (systematic reviews and literature reviews) aiming at identifying the problems that can occur in planning and implanting phases of gamification. In total, six problems were mapped, related to gamification design, as: lack of empirical evidence, lack of definitions, lack of specific methods, customization, undesired behavior, lack of technological support. Furthermore, through the identification of these obstacles, this work provides a base so that future gamification approaches may avoid them during the planning and implementation phases.
Keywords: gamification, systematic review, design

1. Introdução

A gamificação vem sendo usada amplamente em contextos educacionais nos últimos anos (Borges et al., 2014). Definida como a utilização de elementos de jogos fora do contexto de jogos, a gamificação pode ser utilizada para aprimorar a motivação e o engajamento, assim como servir de apoio para processos de ensino e treinamento (Kapp, 2012; Deterding et al., 2011). No contexto educacional, a gamificação está presente tanto em ambientes virtuais de aprendizagem (Toda et al., 2014; Klock et al., 2015; Challco et al., 2016) quanto na própria sala de aula (Toda et al., 2016). Diversos trabalhos discutem os benefícios relacionados ao uso da gamificação em ambientes educacionais, dentre eles os mais citados são a melhoria no engajamento, no processo de aprendizagem ou maestria de habilidades e, também, mudanças positivas de comportamento (Borges et al., 2014). Apesar dos diversos resultados positivos apresentados na literatura, estes só podem ser alcançados a partir de um bom planejamento (Dicheva et al., 2015; Zichermann & Cunningham, 2011; Andrade et al., 2016).

O planejamento e implantação da gamificação é uma importante área de pesquisa e vem recebendo maior atenção nos últimos anos (Nacke & Deterding, 2017). Apesar de sua importância, muitos estudos sobre gamificação não utilizam métodos adequados de planejamento de gamificação que levam em consideração tanto as teorias de design de jogos quanto o contexto onde os elementos de jogos serão utilizados.

Para lidar com esse problema, diversos pesquisadores vêm propondo abordagens sistemáticas como uma forma de auxiliar o design da gamificação. Apesar disso, até o momento existe uma carência de pesquisas que fazem análises aprofundadas sobre os problemas relacionados ao planejamento e implantação da gamificação (Nacke & Deterding, 2017; Kim & Werbach, 2016).

Baseando-se no exposto, este artigo apresenta a seguinte pergunta de pesquisa: "*Quais as principais dificuldades relacionadas ao planejamento e implantação da gamificação em contextos educacionais?*". Para responder esta pergunta de pesquisa, foi realizada uma revisão sistemática da literatura com o intuito de identificar problemas relacionados ao planejamento e implantação da gamificação. Foram analisados onze estudos secundários (revisões de literatura e sistemáticas) e identificados seis problemas.

Para apresentar a proposta, este trabalho está estruturado da seguinte forma: Seção 2 apresenta um conjunto de obstáculos e efeitos colaterais relacionados a gamificação; Seção 3 apresenta o protocolo da revisão; Seção 4 apresenta os resultados encontrados e uma breve discussão; Seção 5 apresenta as conclusões e trabalhos futuros.

2. Efeitos Colaterais da Gamificação na Educação

Problemas encontrados no planejamento e/ou implantação da gamificação são escassos na literatura, grande parte dos trabalhos focam nos problemas pós-implantação, quando mensuram o comportamento intencionado da forma correta. Kim & Werbach (2016)

mapearam um conjunto de problemas éticos relacionados a gamificação de forma geral, como:

- **Exploração**: onde os designers aplicam conceitos de gamificação de forma superficial e não alcançando os benefícios intencionados;
- **Manipulação**: onde a gamificação implementada é utilizada para manipular a mudança de comportamento do usuário;
- **Danos físicos:** onde os elementos de jogos afetam a percepção do usuário podendo causar acidentes;
- **Danos psicológicos:** onde estes mesmos elementos podem gerar ambientes não saudáveis para os envolvidos, como o mal planejamento de um placar;
- **Influência negativa nos traços de personalidade do usuário:** onde os elementos aplicados podem encorajar os jogadores a serem indiferentes quanto a valores humanos fundamentais.

Outro estudo que reporta problemas relacionados a gamificação é o de Thiebes, Lins e Basten (2014). Neste estudo, os autores focam em analisar quatro riscos que a gamificação de sistemas de informação deve considerar quando utilizar os elementos de jogos, sendo:

- **Qualidade da tarefa:** onde a gamificação influencia na qualidade das ações que devem ser desempenhadas, de modo que os elementos de jogos atrapalham ou desviam a atenção do jogador;
- **Enganando o sistema (do inglês, *Cheating the system*):** onde as regras do sistema não são claras, o que permite que os jogadores ignorem-as ou utilize brechas para obter vitória;
- **Privacidade:** onde o monitoramento e vigilância dos dados podem ocasionar brechas de seguranças quanto às informações do sistema, violando direitos de privacidade básicos do usuário;
- **Efeitos declinantes:** pode ocorrer quanto o efeito da gamificação se desgasta com o tempo, devido a falta de inovação ou complexidade dos desafios.

Apesar de haver um mapeamento inicial, estes problemas foram mapeados em contextos diferentes do educacional. Além disso, nem todos possuem evidências empíricas que os reforçam como problemas (Kim & Werbach. 2016), nem podem ser considerados diretamente como parte do planejamento e/ou implementação.

2. Materiais e métodos

Para realizar esta pesquisa foi desenvolvida uma revisão sistemática, buscando estudos secundários (Revisões sistemáticas e de literatura) com foco na área de educação. Foram selecionados estudos secundários por conterem uma coletânea de trabalhos primários, e que passaram por um controle de qualidade durante a realização do estudo (no caso de estudos sistemáticos).

Para realizar a revisão foi utilizado o protocolo desenvolvido por Kitchenham (2004) que consiste em três etapas: Planejamento, onde são definidas as questões de

pesquisa, *strings* de busca, critérios de inclusão e exclusão e bases de coleta; Condução, onde é realizada a busca nas bases selecionadas e aplicação dos critérios de inclusão e exclusão, a fim de selecionar os estudos a serem realizados; Relatório de resultados, onde é realizado o resumo dos resultados encontrados.

Na fase de planejamento foi definida a seguinte pergunta de pesquisa "Quais as principais dificuldades relacionadas ao planejamento e implantação da gamificação em contextos educacionais?". Com relação a busca, foram utilizados termos referentes a estudos secundários e gamificação como "Gamification", "*Meta-analysis*", "*Systematic mapping*", "*Systematic Review*" e "*Literature review*". Em seguida foram definidos os critérios de inclusão e exclusão (Tabela 1) para auxiliar na filtragem dos estudos selecionados.

Tabela 1: critérios de inclusão e exclusão

Critérios de inclusão	**Critérios de exclusão**
Ser do contexto educacional	Fora do contexto educacional
Estar em inglês	Linguagem diferente do inglês
Estar publicado em conferência, capítulo de livro ou periódico	Literatura cinza
Ser um estudo secundário (revisão da literatura ou sistemática)	

Por fim, foram escolhidas bases de pesquisa de referência na área, sendo: *IEEE Xplore, ACM Digital Library, Scopus, Engineering Village, Web of Science* e *ScienceDirect*. Após a fase de Planejamento, foi iniciada a fase de Condução (Figura 1), onde a *string* foi utilizada nas bases de busca. A partir destes termos foram retornados 768 artigos, que foram analisados pelos seus títulos, resumos e palavras-chaves para identificar quais seriam utilizados para serem analisados.

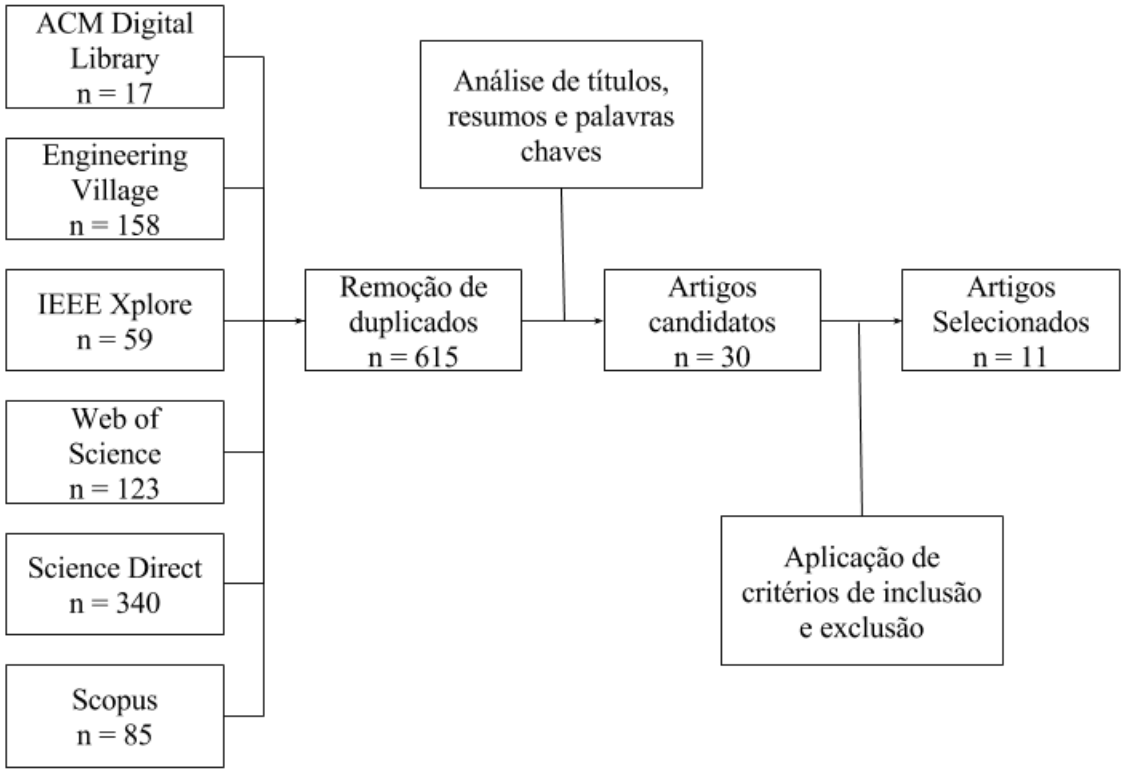

Figura 1: Fases da etapa de condução

Após esta análise, foram identificados 30 trabalhos candidatos que seriam lidos por completo. Em seguida, foram aplicados os critérios de inclusão e exclusão para identificar os estudos que seriam utilizados na pesquisa, totalizando 11 artigos (Borges et al., 2014; Dicheva et al., 2015; Faiella & Ricciardi, 2015; Markopoulos et al., 2015; Azmi, Iahad & Ahmad, 2015; Surendeleg et al., 2014; Al-Smadi, 2015; Busarello et al., 2016; Nah et al., 2014; Caponetto et al., 2014; Samungam et al., 2015). Estes artigos consistem de estudos secundários que abordam a gamificação em contextos educacionais, no entanto diferem quanto ao contexto que são explorados, como aprendizagem colaborativa.

3. Resultados e discussões

Nos onze artigos analisados, foram extraídas informações referentes aos estudos primários e os problemas reportados no planejamento e implantação da gamificação nos contextos de ensino. No total, foram identificados seis problemas relacionados à implantação da gamificação em contextos educacionais, sendo: Carência de evidências empíricas, Carências de métodos específicos, Customização, Comportamento indesejado, Carência de definições e Carência de suporte tecnológico.

Carência de evidências empíricas é caracterizada quando estudos primários analisados não fornecem evidências suficientes para atestar os efeitos benéficos da gamificação implantada. Este problema afeta a credibilidade da gamificação, uma vez que não há uma conexão entre prática e teoria (Seaborn & Fels, 2014). Este problema foi reportado por sete estudos (Borges et al., 2014; Dicheva et al., 2015; Faiella & Ricciardi, 2015; Markopoulos et al., 2015; Azmi, Iahad & Ahmad, 2015; Surendeleg et al, 2014; Caponetto et al., 2015). Um ponto importante neste tópico é quando estudos

primários visam analisar e/ou mensurar comportamentos como motivação e engajamento, mas não apresentam o aporte teórico adequado para avaliarem isto.

Carência de métodos específicos foi identificado por quatro estudos secundários, é relacionado como a necessidade de métricas e ferramentas de avaliação bem definidas. Isto é uma preocupação recorrente em estudos primários, uma vez que a carência de métodos de avaliação prejudicam na avaliação da efetividade da gamificação que foi aplicada. Vários estudos primários focam em avaliar diversas métricas, motivação sendo a principal, porém utilizando instrumentos diferentes e não validados (Dicheva et al., 2015; Faiella & Ricciardi, 2015; Azmi, Iahad & Ahmad, 2015; Nah et al., 2014). Outro ponto levantado neste problema é a discrepância quanto aos instrumentos utilizados, quando há um instrumento validado utilizado, muitos dos instrumentos são feitos de forma ad-hoc sem a validação apropriada, ou não condizem com as teorias de motivação e engajamento que estão sendo utilizadas como base.

Customização é outro problema reportado em estudos secundários de gamificação, é relacionado à propriedade de modificar a experiência do usuário baseado no perfil (demográfico, de jogador ou outro) e/ou suas interações com o sistema gamificado (sistemas tutores inteligentes). Este problema foi reportado por três estudos (Dicheva et al., 2015; Faiella & Ricciardi, 2015; Al-Smadi, 2015). Outro ponto importante relacionado a este problema é a extração e identificação destes perfis. A literatura de jogos apresenta alguns modelos de perfis de jogadores, no entanto nem todos podem ou devem ser utilizados como base para sistemas gamificados.

Comportamento indesejado é uma preocupação em estudos primários de gamificação, é relacionado às mudanças de comportamento que não foram previstas quando a gamificação foi planejada. Dentre estes comportamentos indesejados, os mais citados são uma diminuição na motivação, onde a gamificação provocou o efeito oposto do desejado, ou competição indesejada, onde o processo que foi gamificado gerou uma competição não saudável entre os usuários (Busarello et al., 2016; Sanmugan et al., 2015). Um ponto relevante relacionado a este problema é que algumas abordagens tentaram mapear o comportamento dos usuários das aplicações que intenciona-se gamificar, no entanto em contextos de ensino há uma dificuldade maior neste aspecto, devido a heterogeneidade dos perfis do público-alvo.

Carência de definições foi reportado por dois estudos, é relacionada a carência ou confusão entre os pesquisadores para definir ou expor conceitos básicos de gamificação. Isto foi considerado um problema, uma vez que a carência de termos atrapalha consideravelmente na implantação da gamificação, um exemplo disso são estudos que consideram pontos e conquistas como elementos (Hanus & Fox, 2014; Kapp, 2012; Toda et al., 2014), em outros estudos estes são chamados de recompensas (Lee & Hammer, 2011; Korn & Schmidt, 2015; Markoupolos et al., 2015), ou diferenciam em outras classificações, como elementos de feedback (Kapp, 2012; Toda et al., 2016; Thiebes, Lins & Basten, 2014). Foi reportado por dois estudos (Dicheva et al., 2015; Caponetto et al., 2015).

Essa carência de definições também influencia no desenvolvimento e elaboração de estratégias, uma vez que a discrepância entre os termos pode confundir profissionais do ensino, principalmente os que não tem costume de utilizá-los em seu dia-a-dia. A elaboração de estratégias, assim como o seu registro, é importante para o

desenvolvimento de estudos na área de gamificação, uma vez que o mal mapeamento e definição dos termos também pode prejudicar os design de experimentação para obtenção de evidências empíricas.

Outra preocupação, destacada apenas por Dicheva et al (2015) é a carência de suporte tecnológico que pode atrapalhar ou até mesmo impedir o uso da gamificação em contextos educacionais. Isso é um fator debatido entre os estudos de gamificação, uma vez que há um consenso sobre a quantidade de informações que é possível extrair em ambientes gamificados (Heilbrunn, Herzig & Schill, 2014).

Isso é uma preocupação importante, uma vez que vem surgindo interesse por parte dos profissionais do ensino em implantar a gamificação, no entanto não conseguem pela falta de tempo e recursos (Sánchez-Mena e Martí-Parreño, 2016; Martí-Parreño, Seguí-Mas e Seguí-Mas, 2016). É possível encontrar algumas ferramentas que apoiam etapas do processo de planejamento e implantação da gamificação (Heillbrun, Herzig & Schill, 2014), no entanto nenhuma delas apoia o processo de design do início ao fim.

Com o intuito de realizar uma análise sobre os problemas mais frequentes (respectivamente, Carência de evidências empíricas [CarEvdEmp], Carência de métodos específicos [CarMetEsp], e Customização - [Custom]) foi gerado um diagrama de Venn (Herbele et al., 2015) apontando a intersecção entre os obstáculos relatados, na visão dos estudos secundários analisados (Figura 2).

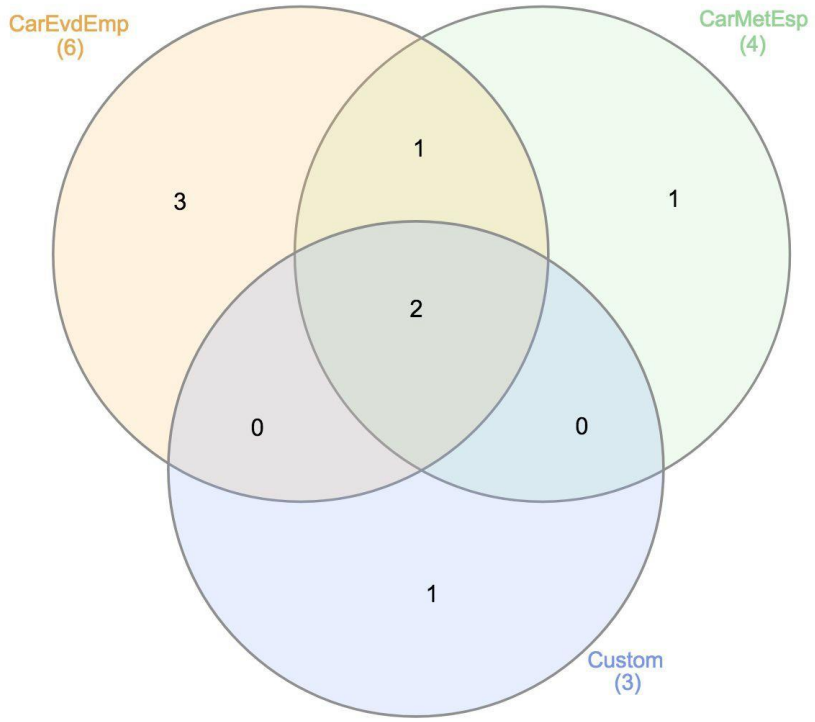

Figura 2: Diagrama de Venn representando a interseção entre os problemas relatados

A partir deste gráfico (Figura 2), pode ser observado que a carência de métodos específicos tem um estudo relacionado com a carência de evidências empíricas, isso deve ocorrer pelo fato de não haver um consenso quanto a métodos e designs de experimentação nos estudos primários de gamificação, o que dificulta na avaliação.

Outra relação é quanto a customização, onde os autores reportam a necessidade de customizar os ambientes gamificados com os perfis de usuário. No entanto, a falta de instrumentos para a mensuração destes perfis e a forma de como avaliá-los também influencia negativamente no resultado empírico dos estudos.

A partir dos resultados encontrados, podemos direcionar pesquisas futuras para o desenvolvimento de modelos e instrumentos de avaliação para as abordagens de gamificação existentes. Uma possível proposta é o desenvolvimento de um modelo que, em conjunto com ferramentas inteligentes de autoria, possa auxiliar pesquisadores e profissionais de ensino na medição dos comportamentos esperados, como motivação e engajamento, e na extração dos perfis de seu público-alvo, para auxiliar na customização.

4. Conclusões, Limitações e Trabalhos Futuros

A gamificação é uma aliada poderosa para melhorar o engajamento e motivação de alunos, no entanto, para alcançar estes benefícios é necessário realizar um bom planejamento. Este trabalho apresentou uma lista de ameaças, com base em uma revisão da literatura aprofundada, que podem prejudicar a implantação da gamificação em contextos educacionais. Dentre os problemas encontrados, pode-se destacar a carência de evidências empíricas como o principal dos problemas, uma vez que foi reportado por sete estudos, seguido pela Carência de métodos específicos reportada por quatro estudos, isto significa que estudos primários devem ter uma atenção maior na preparação do design experimental, como as *guidelines* presentes em Klock et al (2015).

Dentre as limitações do trabalho pode-se citar o critério de inclusão de artigos somente no idioma inglês, isto é considerado uma limitação uma vez que exclui artigos nacionais publicados em periódicos e conferências indexados nas bases escolhidas. A não utilização de bases nacionais para a realização das buscas ocorreu pelo fato destas não aceitarem *strings* de busca como parte do seu mecanismo de busca, dificultando a coleta de artigos.

Este trabalho também apresenta uma contribuição para a área de gamificação, a partir do mapeamento dos problemas encontrados, uma vez que isto ainda não foi encontrado na literatura. Como trabalhos futuros, espera-se utilizar estes problemas para desenvolver critérios para avaliar os *frameworks*, métodos e processos de gamificação, com foco na educação, existentes. Além disso, outro foco de trabalho futuro é realizar uma inclusão manual de estudos secundários encontrados em bases nacionais e outros que não aceitam recursos de busca com *strings* lógicas, como o *Google Scholar*.

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Referências

ANDRADE, F. R.H; MIZOGUCHI, R.; ISOTANI, S. The bright and dark sides of gamification. Proceedings of the International Conference on Intelligent Tutoring Systems, p. 176-186, 2016.

BORGES, S. DE S. et al. A systematic mapping on gamification applied to education. Proceedings of the 29th ACM Symposium on Applied Computing, p. 216-222, 2014.

DETERDING, S. et al. From Game Design Elements to Gamefulness: Defining "Gamification". Proceedings of the ACM annual conference on Human factors in Computing Systems - CHI, p. 9-15, 2011.

DICHEVA, D. et al. Gamification in Education : A Systematic Mapping Study. Educational Technology & Society, v. 18, n. 3, p. 75–88, 2015.

ZICHERMANN, G.; CUNNINGHAM, C. Gamification by Design: Implementing Game Mechanics in Web and Mobile Apps. [s.l.] O'Reilly Media; 1 edition, 2011.

KAPP, K. M. The Gamification of Learning and Instruction: Game-based Methods and Strategies for Training and Education, 2012.

TODA, A. M. et al. Desenvolvimento de uma aplicação web para auxiliar no ensino da Matemática para alunos do Ensino Fundamental. XXV Simpósio Brasileiro de Informática na Educação (SBIE 2014), p. 392-401, 2014

KLOCK, A. C. T. et al. Análise das técnicas de Gamificação em Ambientes Virtuais de Aprendizagem. RENOTE, v. 12, n. 2, 2015.

TODA, A. et al. Um processo de Gamificação para o ensino superior: Experiências em um módulo de Bioquímica. Anais do Workshop de Informática na Escola, p. 495-504, 2016.

CHALLCO, G. C.; MIZOGUCHI, R.; ISOTANI, S. An Ontology Framework to Apply Gamification in CSCL Scenarios as Persuasive Technology. Revista Brasileira de Informática na Educação, v. 24, n. 2, p. 67, 2016.

SEABORN, K.; FELS, D. I. Gamification in Theory and Action: A Survey. Internatoinal Journal of Human-Computer Studies, v. 74, p. 14–31, 2014.

HANUS, M. D.; FOX, J. Assessing the effects of gamification in the classroom: A longitudinal study on intrinsic motivation, social comparison, satisfaction, effort, and academic performance. Computers & Education, v. 80, p. 152–161, 2014.

LEE, J. J.; HAMMER, J. Gamification in Education: What, How, Why Bother? Academic Exchange Quarterly, v. 15, p. 1–5, 2011.

KORN, O.; SCHMIDT, A. Gamification of Business Processes: Re-designing Work in Production and Service Industry. Procedia Manufacturing, v. 3, p. 3424–3431, 2015.

MARKOPOULOS, A. P. et al. Gamification in engineering education and professional training. International Journal of Mechanical Engineering Education, v. 43, n. 2, p. 118–131, 2015.

THIEBES, S.; LINS, S.; BASTEN, D. Gamifying information systems A synthesis of gamification mechanics and dynamics. Proceedings of the 22nd European Conference on Information Systems, p. 1–17, 2014.

HEILBRUNN, B.; HERZIG, P.; SCHILL, A. Tools for Gamification Analytics: A Survey. Proceedings of the IEEE/ACM 7th International Conference on Utility and Cloud Computing, p. 603-608, 2014
FAIELLA, F.; RICCIARDI, M. Gamification and learning: A review of issues and research. Journal of E-Learning and Knowledge Society, v. 11, n. 3, p. 13–21, 2015.
AZMI, S.; IAHAD, N. A.; AHMAD, N. Gamification in online collaborative learning for programming courses: A literature review. v. 10, n. 23, p. 18087–18094, 2015.
SURENDELEG, G. et al. The role of gamification in education–a literature review. Contemporary Engineering Sciences, v. 7, n. 29–32, p. 1609–1616, 2014.
AL-SMADI, M. GAMEDUCATION: Using Gamification Techniques to Engage Learners in Online Learning. Communications in Computer and Information Science, v. 486, p. 85-97, 2015.
BUSARELLO, R. I. et al. Gamification Approaches to Learning and Knowledge Development: A Theorical Review. In: Advances in Intelligent Systems and Computing. [s.l.] Springer International Publishing, 2016. v. 444p. 1107–1116.
NAH, F. F.-H. H. et al. Gamification of education: A review of literature. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics). Anais...Springer International Publishing, p. 401-409 2014.
CAPONETTO, I.; EARP, J.; OTT, M. Gamification and Education: A Literature Review. Proceedings of the European Conference on Games Based Learning, v. 1, n. 2009, p. 50–57, 2014.
SANMUGAM, M. et al. Gamification as an educational technology tool in engaging and motivating students; An analyses review. Advanced Science Letters, v. 21, n. 10, p. 3337–3341, 2015.
NACKE, L. E.; DETERDING, S. The maturing of gamification research. Computers in Human Behavior, v. 71, p. 450–454. 2017.
KIM, T. W.; WERBACH, K. More than just a game: ethical issues in gamification. Ethics and Information Technology, v. 18, n. 2, p. 157–173. 2016.
HEBERLE, H. et al. InteractiVenn: a web-based tool for the analysis of sets through Venn diagrams. BMC Bioinformatics, v. 16, n. 1, p. 169. 2015.
SÁNCHEZ-MENA, A.; MARTÍ-PARREÑO, J. Gamification in higher education: teachers' drivers and barriers. Proceedings of the International Conference of The Future of Education, p. 180-184, 2016.
MARTÍ-PARREÑO, J.; SEGUÍ-MAS, D.; SEGUÍ-MAS, E. Teachers' Attitude towards and Actual Use of Gamification. Procedia - Social and Behavioral Sciences, v. 228, p. 682–688, 2016.
KIM, T. W.; WERBACH, K. More than just a game: ethical issues in gamification. Ethics and Information Technology, v. 18, n. 2, p. 157–173. 2016.

ANNEX

C

DESIGNING GAMIFICATION FOR EDUCATIONAL CONTEXTS: A NATIONAL SYSTEMATIC MAPPING - IN BRAZILIAN PORTUGUESE

Frameworks para o Planejamento da Gamificação em Contextos Educacionais - Uma revisão da literatura nacional

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Resumo. *A gamificação tem sido bastante utilizada para aumentar o engajamento e a motivação dos estudantes em contextos educacionais, ampliando o interesse por parte de professores e instrutores. No entanto, há um consenso na literatura quanto a necessidade de abordagens sistemáticas (métodos, processos e/ou frameworks) para apoiar o planejamento da gamificação, de modo que os seus efeitos benéficos sejam alcançados. A literatura identifica alguns estudos internacionais focados em analisar estas abordagens sistemáticas, no entanto, há uma carência de estudos que relatem como o Brasil tem contribuído para o processo de planejamento da gamificação. Diante disso, esse artigo tem por objetivo apresentar um mapeamento sistemático da literatura, visando identificar as abordagens sistemáticas existentes para o planejamento da gamificação em escala nacional. A partir da condução desse mapeamento, foram encontrados 18 estudos onde foram identificados: (a) uma carência no apoio automatizado para o docente; (b) uma classificação dos tipos de personalização utilizados; e (c) a quantidade de elementos de gamificação utilizados. Por meio dos resultados obtidos, foi possível identificar ainda diversos desafios e oportunidades relacionados a esta área de pesquisa.*

Abstract. *Gamification has established itself as a technology capable of increasing engagement and motivation in educational contexts, increasing the interest of teachers and instructors. Therefore, there is a consensus in the literature about the need for systematic approaches (methods, processes and / or frameworks) for gamification planning, in order to achieve its beneficial effects. The literature present some international studies focused on analyzing these systematic approaches, however, there is a lack of studies that report how Brazil can contribute to this planning process. Based on the exposed, the objective of this article is to present a systematic mapping of the literature, aiming to identify the existing nationwide approaches to the planning of gamification. From the conduction of this mapping, 18 studies were found. From these studies, we identified: (a) a lack of automated support for the teacher; (b) a classification of the types of personalization used; and (c) the amount of elements used. Through the results, it was also possible to identify several challenges and opportunities related to this area of research.*

1. Introdução

Nos últimos anos, a gamificação vem se consolidando como uma tecnologia de apoio educacional para auxiliar, engajar e motivar os alunos em ambientes educacionais [Dichev and Dicheva 2017]. Isto tem atraído a atenção de professores, instrutores que, por sua vez, em geral, não possuem tempo, recursos ou conhecimento necessário sobre gamificação para planejar e executar as tarefas gamificadas em seus contextos educacionais [Paula e Fávero 2016, Martí-Parreño *et al*. 2016, Sánchez-Mena and Martí-Parreño 2016].

Para alcançar os efeitos positivos referentes a motivação e engajamento, a gamificação necessita de um bom planejamento, de forma sistemática, [Zichermann and Cunningham 2011, Toda et al., 2018], assim como considerar a personalização [Santos, Bittencourt & Vassileva, 2018, Monterrat et al. 2014], elementos de jogos utilizados e formas para automatizar o planejamento para auxiliar o docente [Toda et al. 2018]. Além disso, também é discutido na literatura que um bom design gamificado (isto é, a união dos elementos de jogos com os objetivos a serem alcançados) pode evitar efeitos nocivos que a gamificação pode ocasionar, como a indiferença, perda de desempenho, comportamentos indesejados e efeitos declinantes, como a falta de motivação e engajamento [Toda, Valle & Isotani, 2017].

No entanto, no contexto educacional, sabe-se que existem poucos estudos que analisam abordagens sistemáticas (nesse estudo, adotamos a definição de abordagem sistemática como processos, métodos, estratégias, *frameworks* e outras formas sequenciais que auxiliassem na implantação) focadas no planejamento da gamificação, além de que grande parte foi criada para atender domínios específicos, sem considerar o professor como parte do processo [Mora et al. 2017]. Além disso, a gamificação tem sido amplamente explorada por meio de estudos secundários (revisões sistemáticas, mapeamentos sistemáticos e revisões da literatura) [Borges et al. 2014, Klock et al. 2015, Toda et al. 2017].

No entanto, grande parte destes estudos focam na gamificação em escala global, que, por restrições de protocolo (*e.g.,* considerar trabalhos apenas no idioma inglês), nos impede de verificar as abordagens sistemáticas que têm sido desenvolvidas em escala nacional, ou seja artigos em português, de veículos de publicação brasileira e publicados por pesquisadores brasileiros e de instituições brasileiras. Por fim, estes estudos não analisam e/ou debatem como essas abordagens sistemáticas de gamificação lidam com aspectos relacionados ao apoio ao professor (*e.g.*, se existe alguma forma de automatizar o processo e/ou o planejamento) e personalização (*e.g.*, se aspectos de personalização da gamificação com base nos usuários são considerados), nem mesmo têm identificado os elementos utilizados (fundamental para desenvolver as estratégias gamificadas [Zichermann & Cunninghan, 2011]. Baseando-se no exposto, conduzimos um mapeamento sistemático, com o objetivo de identificar estes aspectos relacionados a: (a) apoio computacional ao professor/ instrutor; (b) personalização da gamificação; e (c) elementos utilizados.

2. Protocolo

Para a realização desta pesquisa, foram utilizadas as diretrizes propostas por Kitchenham (2004), para o desenvolvimento de estudos secundários. Estas diretrizes são divididas em três fases, sendo: **Planejamento**, onde são definidas as Questões de Pesquisa (QP), a *string* de busca, os Critérios de Inclusão (IC) e Exclusão (EC), e as bases de pesquisa; **Condução**, onde a *string* de busca é utilizada nas bases de pesquisa selecionadas, e são aplicados os ICs e ECs; e **Relatório dos Resultados**, onde é realizado uma exposição dos resultados encontrados. Para nortear o nosso trabalho, desenvolvemos a seguinte questão de pesquisa principal *"Que abordagens estão sendo desenvolvidas no cenário nacional?"*, em seguida definimos as questões de pesquisa que seriam respondidas pelo mapeamento, com o intuito de responder a questão principal. No planejamento, foram definidas as seguintes QP.

- **QP1:** Existem tecnologias computacionais que automatizam a abordagem para apoiar o processo de planejamento nas abordagens analisadas?
- **QP2:** Existem formas de personalizar a gamificação nas abordagens analisadas? Se existem, quais?
- **QP3:** Quantos elementos de de jogos são considerados nestas abordagens?

Em seguida, definimos os termos da *string* de busca. Para as abordagens, optamos pelos termos "abordagem", "estratégia", "*framework*", "método", "processo",

"metodologia", "planejamento", "técnica" em combinação com os termos "gamificação" e "*gamification*". Com relação às bases de pesquisa, foram escolhidas a CEIE[1], revista RENOTE[2] e Scopus, por concentrarem grande parte das pesquisas em informática na educação no país, além de serem as bases mais utilizadas em outras revisões realizadas em âmbito nacional [Morais et al. 2017, Lima et al. 2017]. Nossa *string* foi ainda adaptada e traduzida para a base da Scopus, utilizando os termos "*approach*", "*strategy*", "*framework*", "*method*", "*process*", "*methodology*", "*planning*", "*technique*" e "*gamification*", e os resultados foram filtrados por país de origem.

Após a definição da *string* e das bases de pesquisa, foram definidos os IC e EC. Foram considerados estudos completos que: *(i)* apresentam algum tipo de abordagem sistemática para o planejamento da gamificação em contexto educacional; *(ii)* fossem conduzidos no Brasil; e *(iii)* fossem desenvolvidos por universidades brasileiras. Como EC, consideramos estudos que: *(i)* não apresentam algum tipo de abordagem sistemática para o planejamento da gamificação; *(ii)* não foram conduzidos no Brasil ou por pesquisadores brasileiros; (*iii)* façam parte da literatura cinza, ou seja, em bases não indexadas e trabalhos de conclusão (como dissertações e teses). O planejamento do protocolo foi validado por 2 especialistas da área de gamificação e em estudos secundários.

3. Resultados e Discussão

O processo das buscas ocorreu entre o período de março de 2018 e abril de 2018, sendo conduzido por dois especialistas em gamificação e em estudos secundários. Ao utilizar a *string* de busca nas bases selecionadas, 61 estudos foram retornados. Em seguida, os especialistas realizaram a leitura dos títulos, resumos e palavras-chaves de todos os artigos, para identificar os estudos candidatos a serem analisados. Caso houvesse uma discrepância, haveria um debate até alcançar um consenso. Após esta análise, foram eleitos 29 estudos candidatos. Os demais 32 artigos foram excluídos por não descreverem ou focarem em uma abordagem sistemática que poderia ser analisada. Por fim, os especialistas realizaram a leitura completa dos 29 estudos candidatos e, após a aplicação dos IC e EC, 18 estudos foram selecionados. Um resumo com as informações dos artigos pode ser encontrado em https://goo.gl/AT98oQ . A Tabela 1 apresenta os 18 estudos analisados e, a partir deles, esta seção discorre sobre como eles foram capazes de responder às questões de pesquisas definidas anteriormente.

Tabela 1: Lista de estudos analisados

ID	Título	Referência
P1	*An innovative augmented reality educational framework with gamification to assist the learning process of children with intellectual disabilities*	[Colpani and Homem 2015]
P2	Requisitos para aplicações gamificadas e de realidade alternada para alfabetização e aquisição da linguagem em crianças com síndrome de down	[Souza et al. 2017]
P3	Um modelo para promover o engajamento estudantil no aprendizado de programação utilizando *gamification*	[Silva et al. 2016]
P4	Um processo de gamificação para o ensino superior: experiências em um módulo de bioquímica	[Toda et al. 2016]
P5	*Game elements in a software engineering study group: a case study*	[Matsubara and Silva 2017]
P6	Gamificação aplicada ao ensino de gerência de projetos de	[Ferreira et al.

	software	2016]
P7	Educação empreendedora em uma plataforma tecnológica ludificada: um estudo de caso	[Costa et al. 2017]
P8	*Gamification: a new multimodal approach to education*	[Orlandi et al. 2018]
P9	BROAD-PLG: modelo computacional para construção de jogos educacionais	[Martins et al. 2015]
P10	A gamificação aplicada em ambientes de aprendizagem	[Fardo 2013]
P11	*Gamification in education: a methodology to identify student's profile*	[Freitas et al. 2017]
P12	*5W2H framework: A guide to design, develop and evaluate the user-centered gamification*	[Klock et al. 2016]
P13	Gamificação e avaliação do engajamento dos estudantes em uma disciplina técnica de curso de graduação	[Freitas et al. 2016]
P14	Gamificação na educação: um modelo conceitual de apoio ao planejamento em uma proposta pedagógica	[Gonçalves et al. 2016]
P15	*An ontology framework to apply gamification in CSCL scenarios as persuasive technology*	[Challco et al. 2016]
P16	*A link between worlds: towards a conceptual framework for bridging player and learner roles in gamified collaborative learning contexts*	[Borges et al. 2016]
P17	Um modelo conceitual para a gamificação de ambientes virtuais de aprendizagem	[Klock et al. 2015]
P18	Gamificando a sala de aula: desafios e possibilidades em uma disciplina experimental de Pensamento Computacional no ensino fundamental	[Gomes and Tedesco, 2017]

3.1 QP1: Existem tecnologias computacionais para apoiar o processo de planejamento nas abordagens analisadas?

A QP1 foi responsável por verificar se as abordagens encontradas apresentavam alguma forma de automatização do processo de planejamento da gamificação através de ferramentas computacionais para apoiar o professor ou instrutor. Dentre as 18 abordagens sistemáticas analisadas, nenhuma apresentou tal conceito. Em comparação com os seis *frameworks* focados no contexto educacional encontrados por Mora et al. (2017), também pode-se observar que nenhum deles tinha o professor como foco ou parte do processo de planejamento, ou apresentava alguma forma de automatizar esse processo.

Esse resultado pode ser justificado pelo fato da área de gamificação ainda ser considerada recente, com o conceito ganhando destaque em 2011 [Deterding et al. 2011]. No entanto, com o crescente interesse por parte de professores e instrutores [Martí-Parreño et al. 2016, Paula and Fávero 2016, Sánchez-Mena and Martí-Parreño 2016], é necessário voltar esforços para apoiar o processo de planejamento de forma automática. Isto pode ser apoiado pelo uso de ferramentas de autoria [Dermeval et al. 2018] ou através do uso de sistemas de recomendação apoiados por dados (*Data-driven gamification design*). Com isso, acredita-se que seria possível reduzir o esforço e, consequentemente, tempo necessários pelo professor para a implantação de atividades gamificadas em seu contexto educacional.

3.2 QP2: Existem formas de personalizar a gamificação nas abordagens analisadas?

A QP2 buscou identificar aspectos relacionados a personalização e como estes são apresentados nas abordagens sistemáticas analisadas, por exemplo, os tipos de perfil de usuário utilizados. Dos estudos analisados, apenas 7 (38,9%) apresentaram algum conceito relacionado a personalização. Dentre estes estudos, identificamos três tipos de perfis (Figura 1), sendo:

- **Perfis de jogador:** utilizam tipologias baseadas em preferências e motivações dos usuários enquanto jogam (P3, P11, P12, P15, P16, P18);
- **Perfil demográfico:** consideram aspectos como idade e gênero para o planejamento da gamificação (P11, P18);
- ***Papéis:*** são abordadas as partes relacionadas ao processo, como professor e aluno (P17).

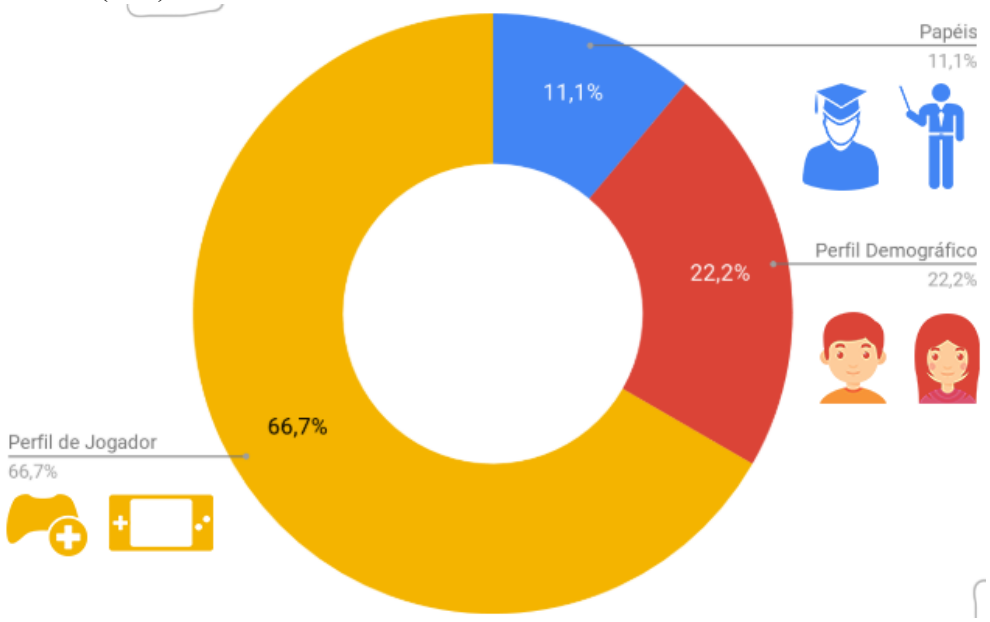

Figura 1: Formas de Personalização encontradas.

A partir da análise destes estudos, pode-se observar que nenhum deles fornece alguma forma de como gamificar o contexto com base no perfil que é citado. Já com relação a identificação dos perfis, esta é sempre realizada através de questionários. Em seguida, realizamos uma comparação com os *frameworks* (focados no domínio de educação) analisados no estudo de Mora et al. (2017), pode-se observar que todos os *frameworks* analisados pelos autores também abordam algum tipo de personalização com base no perfil (atributo *profiling*), porém, apenas um (de seis) desenvolve a proposta de como utilizar elementos de jogos com base no perfil de jogador [Klock et al. 2016].

Esse resultado era esperado, uma vez que a personalização é uma característica essencial a ser considerada em estudos de gamificação [Santos, Bittencourt & Vassileva, 2018]. Sabe-se que é necessário desenvolver estratégias que se adequem e/ou adaptem ao perfil dos usuários do sistema [Borges et al. 2016]. No entanto, ainda há uma carência de estudos que auxiliem em "como" gerar estas estratégias com base nestes perfis. Também é possível observar que a captação e análise destes perfis ainda é feita de forma manual (*e.g.*, através de questionários), e automatizar este processo poderia também reduzir a carga necessária de tarefas relacionadas ao professor.

3.3 QP3: Quantos elementos de jogos são considerados nas abordagens propostas?

A QP3 visa identificar como a abordagem identifica e/ou classifica os elementos de jogos utilizados. Dentre os 18 estudos analisados, 7 (38,9%) não identifica explicitamente quais elementos de jogos são utilizados, 3 (16,7%) criam classificações para os elementos, e os outros 8 estudos (44,4%) apresentam uma lista avulsa com os elementos utilizados. Destes 11 estudos que apresentam elementos de jogos em suas descrições, 6 apresentam menos de 10 elementos de jogos (com um mínimo de 6 elementos), enquanto que as 5 demais apresentam mais de 10 elementos de jogos (com um máximo de 21 elementos).

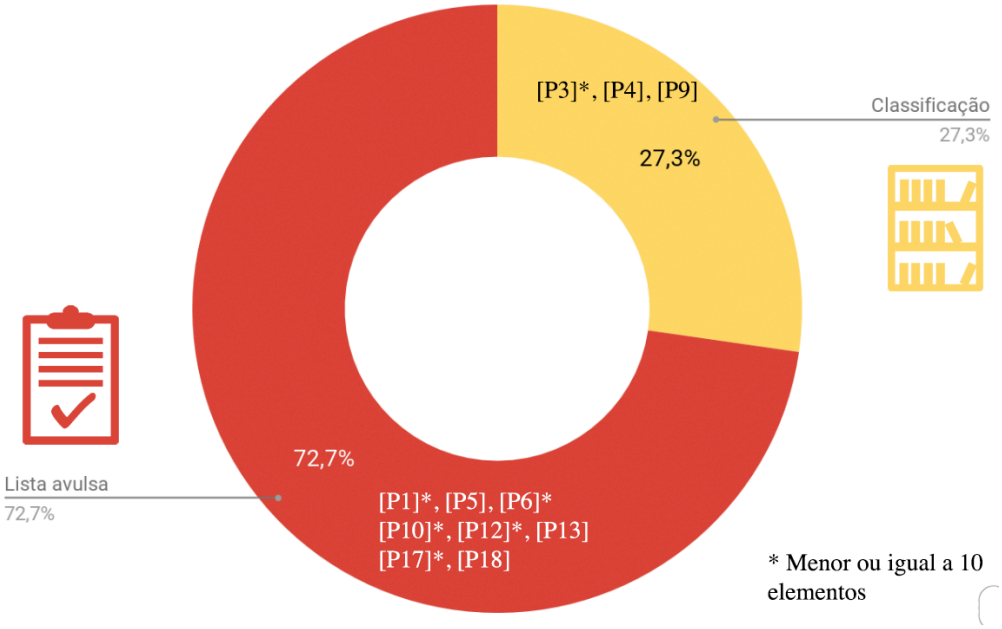

Figura 2: Representação e quantidade de elementos de jogos por abordagem sistemática

Realizamos a análise do número de elementos por abordagem pois esta vem sendo debatida nos últimos estudos relevantes da área [Dichev & Dicheva, 2017]. Acreditamos que o número de elementos também é uma informação importante para o professor/instrutor escolher uma abordagem, uma vez que o tempo para planejamento pode ser afetado pelo número de elementos que serão analisados e combinados pelo docente. Além disso, vale ressaltar que nas 11 abordagens, que apresentaram elementos de jogos, foram encontrados os elementos Pontos, Níveis e Placares. Esta análise pelo número de elementos não foi realizada por Mora et al. (2017), no entanto, os autores identificam nos estudos se eles abordam o conceito de "ciclos de engajamento". Este conceito define como os elementos de jogos são interligados com as atividades desenvolvidas para engajar o usuário.

Dentre os *frameworks* analisados por Mora et al. (2017), nenhum abordou os ciclos de engajamento e o mesmo pode ser observado nos 18 estudos analisados nesta revisão. Apesar de alguns conterem uma listagem com os elementos de jogos, não é detalhado como realizar a ligação entre estes elementos para gamificar as atividades a fim de atingir os objetivos propostos. No entanto, alguns dos estudos apresentam instâncias de como podem ser utilizados em seus contextos, apontando possíveis ciclos de engajamento [Toda et al. 2016, Klock et al. 2016].

Quanto ao número de elementos utilizados, acredita-se que a informação é relevante para auxiliar o professor no processo de planejamento, uma vez que alguns dos principais fatores que os afasta são tempo e conhecimento para preparação de recursos [Sánchez-Mena and Martí-Parreño 2016]. Além disso, esse número pode ser insignificante se a proposta sistemática não abordar como utilizá-los através de

exemplos e/ou instâncias. A discrepância no número de elementos também é encontrada em outros estudos de gamificação, onde ainda há um debate quanto ao melhor número de elementos para alcançar os objetivos propostos [Dichev and Dicheva 2017, Seaborn and Fels 2014].

4. Desafios, Oportunidades e Direcionamentos de Pesquisa para o Planejamento da Gamificação em Cenários Educacionais

A partir da análise das abordagens sistemáticas, pode-se verificar que existem ainda desafios a serem superados. Dentre estes, a carência de ferramentas que auxiliem no processo de planejamento da gamificação. Tal desafio impacta diretamente na adoção da gamificação por professores e instrutores, uma vez que há o obstáculo relacionado ao tempo e conhecimento para o planejamento e implantação da gamificação. Diante desse desafio, surge como oportunidade de pesquisa com foco em sistemas de autoria e de recomendação para auxiliar o professor e instrutor a planejarem a gamificação da forma mais adequada. A partir do uso de sistemas de autoria, por exemplo, o professor pode desenvolver suas próprias estratégias gamificadas baseadas em propriedades previamente definidas. Já os sistemas de recomendação podem fornecer estratégias de gamificação com base no contexto em que o professor deseja aplicá-las [Meder et al. 2017].

Outro desafio percebido está relacionado a personalização da gamificação, uma vez que esta é importante para alcançar a motivação individual dos estudantes [Santos, Bittencourt & Vassileva, 2018, Monterrat et al. 2014]. Apesar de existir uma preocupação quanto ao uso de diferentes perfis e sua extração, ainda não há uma forma sistemática que explique como utilizar os elementos de jogos mais apropriados para perfis específicos, nem mesmo um padrão relacionado aos perfis usados e como gamificar de maneira efetiva para cada um dos perfis. Por fim, não há formas presentes na literatura encontrada de como auxiliar o professor neste processo. Nesse sentido, a área de mineração de dados surge como uma possibilidade computacional para propor maneiras de adequar-se aos diferentes perfis de jogadores e suas condições psicológicas, sociais e humanas. A partir da utilização de técnicas de Mineração de dados, como os algoritmos de predição em bases de dados de sistemas gamificados, pode ser possível identificar estratégias com base nos perfis demográficos dos sistemas, como a preferência de elementos de jogos conforme o gênero dos usuários [Meder et al. 2017].

No que cerne aos elementos de jogos, é possível notar uma discrepância na quantidade de elementos utilizados entre as abordagens analisadas. Tal situação pode prejudicar o entendimento da gamificação por parte dos professores, uma vez que diversos desses elementos possuem conceitos similares (como conquistas e medalhas, ou *ranking* e placar). Além disso, é válido ressaltar que apesar de apresentarem uma listagem e/ou classificação dos elementos utilizados em cada abordagem, a grande maioria não apresenta diretrizes de como aplicá-los na prática. Dessa forma, surge o desafio de relacionar estes elementos de acordo com sua funcionalidade, objetivo, estratégias de *design*, entre outros. Nessa direção, o uso de ontologias e outras tecnologias relacionadas a engenharia do conhecimento, podem auxiliar a eliminar redundâncias [Challco et al. 2016]. Além disso, não há estudo empírico que ateste a causalidade do número de elementos com a adoção da gamificação pelo professor ou instrutor.

5. Limitações, Considerações Finais, e Trabalhos Futuros

A partir do mapeamento sistemático conduzido, acredita-se que prover evidências de que não há tecnologias computacionais para apoiar o professor no processo de planejamento da gamificação está entre as principais contribuições. Outra contribuição foi a classificação nas formas de personalização abordadas, ressaltando que esta forma de personalização refere-se às características do usuário adotadas para a personalização, e não algoritmos. Também foi realizada uma análise das abordagens sistemáticas quanto

ao uso de elementos de jogos e de aplicações práticas. Por fim, são propostas oportunidades e direcionamentos com base nos resultados obtidos.

Dentre as ameaças a validade do estudo, destaca-se a abstração de realizar este tipo de estudo secundário, onde podem ocorrer decisões subjetivas. Com o intuito de mitigar possíveis decisões enviesadas, todos os estudos foram discutidos entre os pesquisadores para alcançar um consenso quanto às informações analisadas. Outra ameaça estaria relacionada a ausência de algumas bases de pesquisa comuns na área de computação. Para contornar este viés, utilizamos a *Scopus*, que indexa diversas bases científicas como Springer e IEEE, filtrando os trabalhos para aqueles desenvolvidos em território nacional.

Como trabalhos futuros, pretende-se analisar as instâncias destas abordagens sistemáticas, com relação às propriedades das avaliações e aplicações na prática (*e.g.*, qual o tipo de avaliação ou como foi realizado o experimento? quais os sujeitos e suas características?). A partir da análise das abordagens sistemáticas presentes, pretende-se desenvolver um *framework* computacional que auxilie na automatização do planejamento da gamificação, utilizando sistemas de autoria e algoritmos de recomendação, além de um processo que permita a detecção e geração de estratégias de gamificação automáticas com base na personalização do usuário.

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Referências

Borges, S. de S., Durelli, V. H. S., Reis, H. M. and Isotani, S. (2014). A systematic mapping on gamification applied to education. In *Proceedings of the 29th Annual ACM Symposium on Applied Computing - SAC '14*.

Dermeval, D., Albuquerque, J., Bittencourt, I. I., et al. (2018). Amplifying Teachers Intelligence in the Design of Gamified Intelligent Tutoring Systems. In *Artificial Intelligence in Education*. . Springer International Publishing.

Deterding, S., Dixon, D., Khaled, R. and Nacke, L. (2011). From game design elements to gamefulness: defining gamification. In *Proceedings of the 15th international academic MindTrek conference: Envisioning future media environments*. ACM.

Dichev, C. and Dicheva, D. (2017). Gamifying education: what is known, what is believed and what remains uncertain: a critical review. *International Journal of Educational Technology in Higher Education*, v. 14, n. 1, p. 9.

Kitchenham, B. (2004). Procedures for Performing Systematic Reviews. Keele University.

Klock, A. C. T., de Carvalho, M. F., Rosa, B. E. and Gasparini, I. (2015). Análise das técnicas de gamificação em ambientes virtuais de aprendizagem. *RENOTE*, v. 12, n. 2.

Klock, A. C. T., Klock, da Cunha, L. F. and Gasparini, I. (2015). Um modelo conceitual para a gamificação de Ambientes Virtuais de Aprendizagem. *RENOTE*, v. 13, n. 1.

Klock, A. C. T., Gasparini, I. and Pimenta, M. S. (2016). 5W2H framework: a guide to design, develop and evaluate the user-centered Gamification. In *Proceedings of the 15th Brazilian Symposium on Human Factors in Computing Systems*. , IHC '16. ACM.

Lima, D., Netto, J. F. and Menezes, C. D. (2017). Agentes inteligentes e sistemas multiagentes: um mapeamento sistemático focado nas iniciativas brasileiras. In

Brazilian Symposium on Computers in Education (Simpósio Brasileiro de Informática na Educação - SBIE).
Martí-Parreño, J., Seguí-Mas, D. and Seguí-Mas, E. (2016). Teachers' attitude towards and actual use of gamification. *Procedia - Social and Behavioral Sciences*, v. 228, p. 682–688.
Meder, M., Plumbaum, T. and Albayrak, S. (2017). A primer on data-driven gamification design. In *Proceedings of the Data-Driven Gamification Design Workshop*.
Monterrat, B., Lavoué, É. and George, S. (2014). A framework to adapt gamification in learning environments. In *European Conference on Technology Enhanced Learning*. Springer.
Mora, A., Riera, D., González, C. and Arnedo-Moreno, J. (2017). Gamification: a systematic review of design frameworks. *Journal of Computing in Higher Education*,
Santos, W. O., Bittencourt, I. I., & Vassileva, J. (2018). Design of Tailored Gamified Educational Systems Based on Gamer Types. In Anais dos Workshops do Congresso Brasileiro de Informática na Educação (Vol. 7, No. 1, p. 42).
Paula, F. R. D. and Fávero, R. da P. (2016). A gamificação da educação na compreensão dos profissionais da educação. *Proceedings of 15th SBGames*, p. 1459–1465.
Sánchez-Mena, A. and Martí-Parreño, J. (2016). Gamification in higher education: teachers' drivers and barriers. *Proceedings of the International Conference of The Future of Education*, n. July.
Seaborn, K. and Fels, D. I. (2014). Gamification in theory and action: a survey. *International Journal of Human-Computer Studies*, v. 74, p. 14–31.
Toda, A., Rafael, Y., Cruz, W., Xavier, L. and Isotani, S. (2016). Um processo de gamificação para o ensino superior: experiências em um módulo de bioquímica. In *Anais do Workshop de Informática na Escola*.
Toda, A. M., Valle, P. H. D., & Isotani, S. (2017). The Dark Side of Gamification: An Overview of Negative Effects of Gamification in Education. In *HEFA 2017: Higher Education for All. From Challenges to Novel Technology-Enhanced Solutions* (pp. 143–156). Springer, Cham.
Toda, A. M., da Silva, A. P. and Isotani, S. (2017). Desafios para o Planejamento e Implantação da Gamificação no Contexto Educacional. *RENOTE*, v. 15, n. 2.
Toda, A. M., Do Carmo, R. M. C., Da Silva, A. P., Bittencourt, I. I. and Isotani, S. (2018). An approach for planning and deploying gamification concepts with social networks within educational contexts. *International Journal of Information Management*,
Zichermann, G. and Cunningham, C. (2011). *Gamification by Design: Implementing Game Mechanics in Web and Mobile Apps*. O'Reilly Media; 1 edition.

Apêndice - Referência dos artigos selecionados

Borges, S. de S., Mizoguchi, R., Durelli, V. H. S., Bittencourt, I. I. and Isotani, S. (2016). A link between worlds: Towards a conceptual framework for bridging player and learner roles in gamified collaborative learning contexts. In *Communications in Computer and Information Science*. Springer Verlag.
Challco, G. C., Mizoguchi, R. and Isotani, S. (2016). An ontology framework to apply gamification in CSCL scenarios as persuasive technology. *Revista Brasileira de Informática na Educação*, v. 24, n. 02, p. 67.
Colpani, R. and Homem, M. R. P. (2015). An innovative augmented reality educational framework with gamification to assist the learning process of children with

intellectual disabilities. In *Proceedings of the 6th International Conference on Information, Intelligence, Systems and Applications (IISA)*. IEEE.

Costa, H., Ferneda, E., and do Prado, H. A. (2017). Educação empreendedora em uma plataforma tecnológica ludificada: um estudo de caso. *RENOTE*, v. 15, n. 1.

Fardo, M. L. (2013). A gamificação aplicada em ambientes de aprendizagem. *RENOTE*, v. 11, n. 1.

Ferreira, L., Inocêncio, A. C., Júnior, P. A. P. and Lopes, M. M. (2016). Gamificação aplicada ao ensino de gerência de projetos de software. In *Anais do Workshop de Informática na Escola*.

Freitas, S. A. A., Lacerda, A. R. T., Calado, P. M. R. O., Lima, T. S. and Canedo, E. D. (2017). Gamification in education: A methodology to identify student's profile. In *Proceedings - Frontiers in Education Conference, FIE*. IEEE.

Freitas, S. D., Lima, T., Canedo, E. and Costa, R. L. (2016). Gamificação e avaliação do engajamento dos estudantes em uma disciplina técnica de curso de graduação. In *Brazilian Symposium on Computers in Education (Simpósio Brasileiro de Informática na Educação - SBIE)*.

Gomes, T., & Tedesco, P. (2017). Gamificando a sala de aula: desafios e possibilidades em uma disciplina experimental de Pensamento Computacional no ensino fundamental. In *Anais do Workshop de Informática na Escola*.

Gonçalves, L., Giacomazzo, G., Rodrigues, F. and Macaia, B. (2016). Gamificação na Educação: um modelo conceitual de apoio ao planejamento em uma proposta pedagógica. In *Brazilian Symposium on Computers in Education (Simpósio Brasileiro de Informática na Educação - SBIE)*.

Klock, A. C. T., Gasparini, I. and Pimenta, M. S. (2016). 5W2H framework: a guide to design, develop and evaluate the user-centered Gamification. In *Proceedings of the 15th Brazilian Symposium on Human Factors in Computing Systems*. , IHC '16. ACM.

Martins, G., Campos, F., Braga, R. and David, J. (2015). BROAD-PLG: Modelo Computacional para Construção de Jogos Educacionais. In *Brazilian Symposium on Computers in Education (Simpósio Brasileiro de Informática na Educação - SBIE)*.

Matsubara, P. G. F. and Silva, C. L. C. D. (2017). Game Elements in a Software Engineering Study Group: A Case Study. In *Proceedings of the 2017 IEEE/ACM 39th International Conference on Software Engineering: Software Engineering Education and Training Track (ICSE-SEET)*.

Orlandi, T. R. C., Duque, C. G., Mori, A. M. and de Andrade Lima Orlandi, M. T. (2018). Gamification: a new multimodal approach to education. *Biblios*, n. 70, p. 17–30.

Silva, T., Melo, J. and Tedesco, P. (2016). Um modelo para promover o engajamento estudantil no aprendizado de programação utilizando gamification. In *Anais dos Workshops do Congresso Brasileiro de Informática na Educação*.

Souza, I. D., Moura, A. and Ghirello-Pires, C. (2017). Requisitos para Aplicações Gamificadas e de Realidade Alternada para Alfabetização e Aquisição da Linguagem em Crianças com Síndrome de Down. In *Brazilian Symposium on Computers in Education (Simpósio Brasileiro de Informática na Educação - SBIE)*.

Toda, A., Rafael, Y., Cruz, W., Xavier, L. and Isotani, S. (2016). Um processo de gamificação para o ensino superior: experiências em um módulo de bioquímica. In *Anais do Workshop de Informática na Escola*.

ANNEX

D

A TAXONOMY OF GAME ELEMENTS FOR GAMIFICATION IN EDUCATIONAL CONTEXTS: PROPOSAL AND EVALUATION

2019 IEEE 19th International Conference on Advanced Learning Technologies (ICALT)

A Taxonomy of Game Elements for Gamification in Educational Contexts: Proposal and Evaluation

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***Abstract*—Gamification has been widely employed in the educational domain over the past eight years when the term became a trend. However, the literature states that gamification still lacks formal definitions to support the design of gamified strategies. This paper aims to create a taxonomy for the game elements, based on gamification experts' opinions. After a brief review from existing work, we extract first the game elements from the current state of the art, and then evaluate them via a survey with 19 gamification and education experts. The resulting taxonomy taxonomy included the description of 21 game elements and their quantitative and qualitative evaluation by the experts. Overall, the proposed taxonomy was in general well accepted by most of the experts. They also suggested expanding it with the inclusion of Narrative and Storytelling game elements. Thus, the main contribution of this paper is proposing a *new, confirmed taxonomy to standardise the terminology used to define the game elements as a mean to design and deploy gamification strategies in the educational domain*.**

***Index Terms*—gamification, taxonomy, survey, experts, education**

I. Introduction

The use of gamification strategies in educational contexts has increased over the past few years, due to the fact that it has been shown to improve the student's motivation and engagement [1], [2]. However, since the success of gamification in those contexts relies on a proper design to avoid undesired effects [1], [3], [4], many input variables must be considered by the gamification researchers, to achieve a satisfactory outcome. Some examples of these variables are the students' characteristics (e.g., demographic, psychological and cognitive data) and the game elements to be used to gamify a task [5], [6].

Game elements are characterised in different ways by the literature. One of the most used approaches is through the MDA framework, originated from digital games, which describes the game elements as belonging to one of these categories: Mechanics, Dynamics and Aesthetics [7]. This framework has been adapted to generic gamification framework [8], which do not take into account specifications from educational domains nor present ways and examples of how those elements can be used in those contexts.

Besides, existing gamification frameworks that focus on the education domain present game elements that are tied to particular contexts [9]. For example, Kotini and Tzelepi [10] developed a conceptual framework focusing on Computational Thinking, and the game elements used were tied to the subject and concepts their students needed to learn. Likewise, the framework of Toda et al. [11] proposes a taxonomy for the game elements and evaluated the framework with gamification experts, without verifying the comprehensibility, coverage or examples of each game element.

To address this problem, our work aims to not only present a taxonomy for game elements in the educational domain, but also to evaluate it (via a survey) with specialists. After extracting 19 game elements from the literature, their comprehensibility, description, examples and coverage were evaluated with 19 experts on gamification and education. Another evaluation was conducted with 11 experts, in order to verify the relevance of the game elements for education. This process results in the final taxonomy, which is our recommendation.

Thus, the main contribution of this work is to provide a taxonomy standardising the game elements employed by both gamification in education and educational games, since those elements were also derived from the game design literature. This taxonomy can support the design of gamified strategies in educational domains (e.g., classrooms or computational systems).

The remainder of this paper is structured as follows. Section II introduces the methods and materials that were produced to conduct the study. Section III describes our results, the proposed taxonomy as well as threats to validity. Finally, section IV presents our conclusions and future works.

II. Materials and Methods

This section describes the methods that were used during the pursuing of this research (Figure 1). We first identified and analysed the game elements commonly employed by gamification frameworks focused on educational contexts. Next, we analyse the game elements explored by a framework focusing on Behavioural Games [12] and took them as baseline.

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Dignan's framework for behavioural games was one of the first frameworks to address gamification concepts (although not defined as gamification at the time).

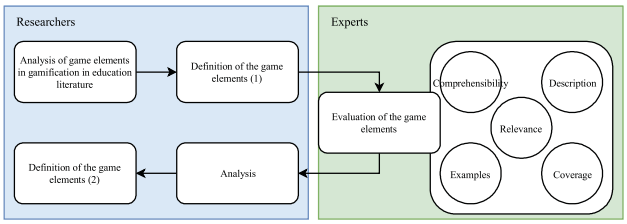

Fig. 1. Steps of the study

To evaluate these game elements, we conducted an online survey with experts[1]. Those experts ranged from game developers, game designers, researchers and teachers. The experts were invited to answer the survey by e-mail and online messages through social networks, in order to make the whole process more convenient for them. The evaluation is composed of five statements, focusing on:

1) **Comprehensibility:** to create a standartised concept for a given group of synonyms of the same element (e.g., *Points* could be allocated as a common denominator, incorporating *Experience Points* as well as *Score*);
2) **Description:** to provide a suitable definition for the game element; this means it has to be both clear, thus specific enough, as well as comprehensive (wide enough to include the semantics of the various synonyms, as above);
3) **Examples:** to provide practical examples of where and how each game element could be used;
4) **Coverage:** to determine if the 19 chosen game elements were sufficient to represent all types of gamification needed in educational environments;
5) **Comments:** to include any additional observation or opinion concerning the given taxonomy, which they felt was needed, in their expert opinion.

Each expert had to answer the above 1 to 4 items through a Likert scale [13] ranged from 1 to 5, where 1 represents *Totally Disagree* while 5 *Totally Agree*. We also asked the experts to make open-ended comments (item 5) on the existing elements; here, they were asked to consider also if they would insert, remove or modify them in any way. Other information collected during the survey included the domain of each expert (e.g., game development or designer, researcher, teacher or instructor, or other) where multiple types of domains could also be selected; and their experience (in years) in that domain.

To analyse the relevance of the game elements to education, we developed another online questionnaire[2] composed of 19 questions – one for each element. It is important to note that not all of the experts answered this questionnaire, since it was optional to participate in this section of the study. This time, the questions consisted of evaluating the relevance of each element.

Each game element is composed of a Concept, a Description defining this Concept, and an Example where this concept is implemented in practice. The Likert scale [13] that was adopted for each game element, ranged from 1 (the element is not relevant) to 5 (the element is highly relevant). An example of a question can be seen in Figure 2. The concept (game element) is displayed in capital letters, followed by its description and examples. Please note that questions were designed to be unbiased (not asking positive or negative questions). Regarding comments, the experts could suggest new game elements and any changes that they thought would be important to the ones that were already presented.

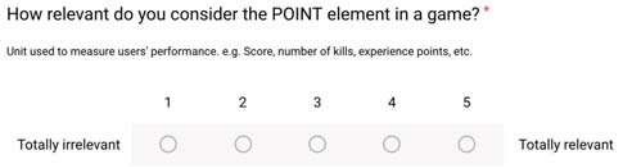

Fig. 2. Example of game element that was analysed by the experts

After the evaluation, we analysed the answers, to propose a taxonomy of game elements used within gamified educational practices. The analysis performed was a semantic analysis [14], where the concepts of each element were re-analysed after the modifications that were suggested by the experts. This analysis also aimed at identifying possible behaviours that those elements could trigger amongst the learners while interacting with those elements.

III. Results and Discussion

A. Results

In total, 19 experts answered our survey. Most of them were researchers (N = 17) and teachers[3] (N = 7), but we also had game developers (N = 3), a designer (N = 1), and an Artificial Intelligence Engineer (N = 1). It is worth to note that the field of expertise was open, so each expert could select more than one field. An overview of the experts' opinions on the game elements can be seen on Table I. We calculated Cronbach's Alpha for each of the aspects; the result suggests a high internal consistency among the 19 experts ($\alpha > 0.8$) [15]. The data used in this study can be found in https://tinyurl.com/y22qrw8g.

TABLE I
Experts' general answers about the game elements

	Likert Scale						
Aspect	**1**	**2**	**3**	**4**	**5**	**Mean**	α
Comprehensibility	7%	10%	0%	21%	62%	4.21	0.84
Description	7%	3%	14%	28%	48%	4.07	0.85
Examples	7%	0%	24%	34%	34%	3.90	0.88
Coverage	7%	14%	7%	31%	41%	3.86	0.90

[1]Available on: urlhttps://forms.gle/DAyMRJfa2gG5HdQF6
[2]Available on: https://goo.gl/forms/LKrc4HF2YKqRZ1xC2
[3]It is important to note that all of the teachers were also researchers.

As we can observe in Table I, the game elements that were analysed had an overall good acceptance in their coverage, which means that the majority of the experts agreed that the 19 game elements could represent well the entire set required for educational applications. Additionally, the game designer suggested to include two new game elements as part of the elements set: *Narrative* and *Storytelling* (which was suggested by 4 out of the 19 experts that answered our survey). There were also some minor changes related to the game elements terminology. These two new game elements were considered important by the authors, because, as concepts, they are intrinsically connected to human behaviour and our necessity of telling stories, as stated by Ricoeur [16]. Thus, both elements were included in the proposed taxonomy.

The *narrative* can be defined as a sequence of events transmitted by a subject. This sequence can be modified in quantitative and qualitative ways (e.g. how this sequence is told, or its storytelling). It also has a calming function and is directly related to motivation and purpose. We can say that the act of narrating stories merge together a purpose of meaning and constant transformation, by establishing a dialogue with a receptor [17].

To fully understand narrative in games, it is important to observe the role of the narrative as it is lived through the game. In this sense, the narrative begins to unfold from the moment the player reads the title of the game or interacts with its mechanics. Everything is an element that contributes directly, and uniquely, to this narrative experience in games [17].

Scartozzoni [18] explains that to understand the term storytelling, one must realise the difference between the English words 'History' and 'Story'. The first is related to real events, such as the fall of the Roman Empire. The second is a narrative structure, usually linked to fiction, but not necessarily. The act of telling this story can be defined as a chain of logical events, within a structure with certain patterns, whose main points are:

- A break in the routine. Stories are mostly about extraordinary events, as we can see in the steps described in Campbell Hero's Journey [19].
- At least one protagonist must exist, which is the character that people should identify with and can be the avatar in a gamified system.
- At least one antagonist must exist in order to create obstacles for the protagonist. In a gamified system, this can be represented by challenges and tests, for example.
- A story needs a conflict, the tension between opposing elements, to grab users' interest (i.e., engagement). In a gamified system, this can be represented by the learning route itself and the tension generated by the process of understanding and frustration in moments of incomprehension.
- The story must have a plot, with beginning, middle and end, passing through some kind of climax. The term 'plot' is the one used in Storytelling, and is considered essential for the story to make sense to people (i.e., build meaning).

Further qualitative evaluation derived from the survey consisted in analysing the written comments provided by the experts. Although most of the experts agreed on most of the aspects that were evaluated, some of them suggested changing the terms, to improve the comprehensibility of the concept, or to change the examples, for similar reasons.

Furthermore, from the 19 experts, only 11 opted to answer the survey analysing the individual game elements relevance to education. The results are detailed in Table II. According to the results, the experts believe that Objectives, Level and Progression are the most important game elements. Besides, according to Table II, no game element was considered irrelevant by the experts who answered this survey.

TABLE II
RELEVANCE OF EACH SUGGESTED GAME ELEMENT

	Likert Scale						
Game element	**1**	**2**	**3**	**4**	**5**	**Mean**	**SD**
Objectives	0%	0%	0%	23%	77%	4.77	0.44
Level	0%	0%	8%	31%	62%	4.54	0.66
Progression	0%	0%	15%	23%	62%	4.46	0.78
Acknowledgement	0%	0%	15%	62%	23%	4.08	0.86
Point	0%	8%	8%	54%	31%	4.08	0.64
Competition	0%	0%	23%	54%	23%	4.00	0.71
Novelty	0%	0%	15%	69%	15%	4.00	0.58
Data	0%	0%	31%	46%	23%	3.92	0.71
Puzzle	0%	8%	23%	38%	31%	3.92	0.95
Classification	0%	8%	8%	77%	8%	3.85	0.76
Scarcity	0%	8%	23%	46%	23%	3.85	0.9
Sensation	0%	15%	15%	38%	31%	3.85	1.07
Cooperation	0%	0%	31%	62%	8%	3.77	0.69
Time pressure	0%	8%	23%	54%	15%	3.77	0.6
Chance	0%	8%	31%	46%	15%	3.69	0.83
Economy	0%	0%	54%	31%	15%	3.62	0.85
Choice	0%	7%	50%	36%	7%	3.43	0.77
Renovation	8%	15%	15%	54%	8%	3.38	1.12
Social pressure	8%	15%	38%	38%	0%	3.08	0.95

Based on the suggestions from the experts, we proposed a taxonomy composed of 21 game elements (Table III). We conducted a semantic analysis, to identify which learner behaviours these elements may affect, based on their descriptions and instances. Furthermore, we analysed the *engagement* and *motivation* behaviour in those elements, since those are strongly connected to gamification definitions [2]. This analysis consists of reading the instances where these elements were implemented, to extract possible affected behaviours, i.e., the Point element was used by Toda et al. [11] to reinforce positive behaviour and repetitive action – to answer a question correctly. In other words, the Point was used to increase engagement. Another example can be observed using Competition. This concept is usually tied to aims such as motivating and engaging the students through a healthy conflict. In the same work, the authors [11] developed a competition among the students, to motivate them in achieving the learning goals, while also engaging them in performing the activities that were proposed by the teacher.

B. Discussion

Based on our results, we can observe that most of the researchers agree that the game elements selected have good

TABLE III
GAME ELEMENTS AND AFFECTED BEHAVIOUR.

Concept	Description	Affected Behaviour
Acknowledgement	All kind of feedback that praises the players' specific actions. Some examples and synonyms are badges, medals, trophies.	Engagement
Chance	Randomness and probability characteristics to increase or decrease the odds of certain actions or outcomes. Some examples and synonyms are randomnesses, luck, fortune.	Engagement
Competition	When two or more players compete against each other towards a common goal. Some examples and synonyms are Player vs Player, scoreboards, conflict.	Engagement Motivation
Cooperation	When two or more players collaborate to achieve a common goal. Some examples and synonyms are teamwork, co-op missions.	Motivation
Economy	Transactions within the game, monetising game values and other elements. Some examples and synonyms are markets, transaction, exchange.	Engagement
Imposed Choice	Decisions that the player is obliged to make in order to advance the game. Some examples and synonyms are judgements, forced choices. *(not to be confused with Narrative).*	Engagement Motivation
Level	Hierarchical layers present in a game, which provide a gradual way for the player to obtain new advantages as they advance. Some examples and synonyms are character levels, skill level.	Engagement
Narrative	Order of events where they happen in a game. These are choices influenced by the players' actions. Some examples and synonyms are the strategies the player uses to go through a level (stealth or action), also the good or bad actions that influence the ending, karma system. *(not to be confused with Imposed Choice).*	Motivation
Novelty	New, updated information presented to the player continuously. Some examples and synonyms are changes, surprises, updates.	Engagement Motivation
Objectives	Guide the players' actions. Quantifiable or spatial, from short to long term. Some examples and synonyms are missions, quests, milestones.	Engagement Motivation
Point	Unit used to measure users' performance. Some examples and synonyms are scores, number of kills, experience points.	Engagement
Progression	This allows players to locate themselves (and their progress) within a game. Some examples and synonyms are progress bars, maps, steps.	Engagement
Puzzles	Challenges within the game that should make a player think. Some examples and synonyms are actual puzzles, cognitive tasks, mysteries.	Engagement
Rarity	Limited resources and collectables. Some examples and synonyms are limited items, rarity, collection.	Engagement
Renovation	When players are allowed to redo/restart an action. Some examples and synonyms are extra life, boosts, renewal.	Engagement
Reputation	Titles that the player accumulates within the game. Some examples and synonyms are titles, status, classification.	Engagement Motivation
Sensation	Use of players' senses to create new experiences. Some examples and synonyms are visual stimulation, sound stimulation.	Engagement
Social Pressure	Pressure through social interactions with another player (s) (playable and non-playable). Some examples and synonyms are peer pressure, guilds.	Engagement Motivation
Stats	Visible information used by the player, related to their outcomes within the game. Some examples and synonyms are results, health bar, magic bar, HUD, indicators, data from the game presented to the user.	Engagement
Storytelling	It is the way the story of the game is told (as a script). It is told within the game, through text, voice, or sensorial resources. Some examples and synonyms are stories told through animated scenes, audio queues or text queues during the game.	Engagement
Time Pressure	Pressure through time within the game. Some examples and synonyms are countdowns, clock, timer.	Engagement Motivation

comprehensibility, description and coverage. Some of them argued about some examples that could be addressed differently, removed or changed. [4]

According to our findings, most of the researchers considered Objective, Level and Progression as the crucial elements. It is interesting as, in educational domains, it has been shown that the lack of objectives and sense of progression decreases students' motivation and engagement [20]. This means that focusing on the design and development of gamification strategies that address those elements may be a band-aid for this motivation problem (but not for the root of it, since there are other aspects concerning motivation that can't be tackled by the educational environment alone, i.e., classrooms or virtual learning systems).

Our findings suggest that most frameworks do not consider Narrative and Storytelling as essential game elements. From the gamification frameworks focusing on education domains that were analysed by Mora et al. [9], we can observe that only one framework addressed the concept of Narrative [21]. In this paper, we have addressed the concept of Narrative and Storytelling, as they are described in [22].

To discuss our limitations, we use the constructs proposed by Wohlin et al. [23]: Internal, External, Construct and Conclusion. Concerning internal threats, we believe that the experts could be affected by the period the survey was answered, but we believe to have mitigated this by allowing them to answer the questionnaire on their computer at a time that was most convenient to them. Another internal validation issue can relate to the number of questions that were required to be answered, as well as the number of elements to analyse. To mitigate these possible issues, we divided the survey into two, and the second survey (concerning the game elements relevance) was not mandatory to answer, which reduced the number of questions drastically.

[4]The final version of our survey can be found in the following link: https://goo.gl/forms/05utLTSmxZBX7uQA2

Concerning external validity, most of the surveyees are from the same country (Brazil). Due to this fact, we believe that we cannot generalise this evaluation to all contexts, for all countries. Besides, as only 19 experts have answered our survey, this could be considered a low number of responses. Nevertheless, as they were all experts, the numbers are less relevant, and, in fact, this is a relatively high number for expert consultations. As for the construct threat, we thought that the questions could be misunderstood, and, consequently, the answers collected might not support us to validate the taxonomy. To minimise this issue, before applying the survey with the experts, we conducted a syntactic and semantic analysis with three experts in Human-Computer Interaction, Gamification and Digital Games. Finally, for the conclusion validity, we did not evaluate the affected behaviours with all 19 experts. Instead, these behaviours were analysed by the same three experts that analysed the survey applied to the experts.

IV. Final remarks

This work has addressed the definition and evaluation of game elements that can be used in educational contexts. Our main contribution is the taxonomy of elements presented in Table III, where we defined the concept, description and examples for each game element, as well as how they may affect user behaviour. We differ from other works on this topic by: (a) providing an evaluation of the elements by experts, with an overall good acceptance; and (b) mapping possible affected behaviours. We believe that this taxonomy may contribute especially to Human-Computer Interaction, Software Engineer and Gamification applied to education domains.

For future works, we aim at consulting more experts to answer the survey. We are currently exploring the extension of the Narrative concept in Gamification. We are also applying the validated survey to collect the opinions about the game elements above. We believe that this information, along with the use of data mining techniques, may allow us to find patterns that relate the users' characteristics and the game elements these users consider most important. This information may also allow us to provide recommendations on how to apply gamification in specific domains (in this case, education).

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References

[1] C. Dichev and D. Dicheva, "Gamifying education: what is known, what is believed and what remains uncertain: a critical review," p. 9, dec 2017.

[2] K. Seaborn and D. I. Fels, "Gamification in Theory and Action: A Survey," *Internatoinal Journal of Human-Computer Studies*, vol. 74, pp. 14–31, 2014.

[3] G. Zichermann and C. Cunningham, *Gamification by Design: Implementing Game Mechanics in Web and Mobile Apps*. O'Reilly Media; 1 edition, 2011.

[4] A. M. Toda, P. H. D. Valle, and S. Isotani, "The Dark Side of Gamification: An Overview of Negative Effects of Gamification in Education," in *Communications in Computer and Information Science*, vol. 832. Springer, Cham, mar 2018, pp. 143–156. [Online]. Available: http://link.springer.com/10.1007/978-3-319-97934-2_9

[5] W. dos Santos, I. Bittencourt, and J. Vassileva, "Gamification Design to Tailor Gamified Educational Systems Based on Gamer Types," *Anais dos Workshops do Congresso Brasileiro de Informática na Educação 2018*, vol. 7, no. 1, p. 42, oct 2018.

[6] A. Carolina, T. Klock, A. N. Ogawa, and M. S. Pimenta, "Does gamification matter ?" in *Proceedings of the 33rd Annual ACM Symposium on Applied Computing*. New York, New York, USA: ACM Press, 2018, pp. 2006–2012.

[7] R. Hunicke, M. LeBlanc, and R. Zubek, "MDA: A Formal Approach to Game Design and Game Research," *Workshop on Challenges in Game AI*, pp. 1–4, 2004.

[8] K. Werbach and D. Hunter, *For the Win: How Game Thinking Can Revolutionize Your Business*. Wharton Digital Press, 2012.

[9] A. Mora, D. Riera, C. González, and J. Arnedo-Moreno, "Gamification: a systematic review of design frameworks," *Journal of Computing in Higher Education*, 2017. [Online]. Available: http://link.springer.com/10.1007/s12528-017-9150-4

[10] I. Kotini and S. Tzelepi, "A Gamification-Based Framework for Developing Learning Activities of Computational Thinking," in *Gamification in Education and Business*. Cham: Springer International Publishing, 2015, pp. 219–252. [Online]. Available: http://link.springer.com/10.1007/978-3-319-10208-5_12

[11] A. M. Toda, R. M. do Carmo, A. P. da Silva, I. I. Bittencourt, and S. Isotani, "An approach for planning and deploying gamification concepts with social networks within educational contexts," *International Journal of Information Management*, oct 2018. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S0268401218304614

[12] A. Dignan, *Game Frame: Using Games as a Strategy for Success*. Free Press, 2011. [Online]. Available: https://books.google.de/books?id=JJJBlQEACAAJ

[13] L. R.A., "A technique for the measurement of attitudes," *Archives of Psychology*, vol. 140, no. 140, pp. 44–53, 1932. [Online]. Available: http://psycnet.apa.org/record/1933-01885-001

[14] C. Goddard, *Semantic analysis: A practical introduction*. Oxford University Press, 2011.

[15] M. Tavakol and R. Dennick, "Making Sense of Cronbach's Alpha," *International Journal of Medical Education*, vol. 2, pp. 53–55, 2011.

[16] P. Ricoeur, *Time and narrative*. University of Chicago Press, 2010, vol. 1.

[17] P. T. Palomino, "We will hold the line: O Fandom como forma de participação dos fãs no desenvolvimento do universo transmidiático do jogo Mass Effect," Master's thesis, Universidade Federal de São Carlos - UFSCar, 2015.

[18] B. Scartozzoni, "Storytelling e transmídia: afinal, o que é e para que serve," *2011*, 2011.

[19] J. Campbell, *The hero with a thousand faces*. New World Library, 2008, vol. 17.

[20] S. Smith-Robbins, "This Game Sucks: How to Improve the Gamification of Education," *Educause Review*, vol. 46, no. 1, pp. 58 – 59, 2011.

[21] A. C. T. Klock, I. Gasparini, and M. S. Pimenta, "5W2H Framework," in *Proceedings of the 15th Brazilian Symposium on Human Factors in Computer Systems - IHC '16*. New York, New York, USA: ACM Press, 2016, pp. 1–10. [Online]. Available: http://dl.acm.org/citation.cfm?doid=3033701.3033715

[22] P. T. Palomino, A. M. Toda, W. O. dos Santos, A. I. Cristea, and S. Isotani, "Narrative for gamification in education: why should you care?" in *Proceedings of the 19th IEEE International Conference on Advanced Learning Technologies.*, 2019.

[23] C. Wohlin, P. Runeson, M. Höst, M. C. Ohlsson, B. Regnell, and A. Wesslén, "Experimentation in software engineering: an introduction," jan 2000. [Online]. Available: http://dl.acm.org/citation.cfm?id=330775

ANNEX

E

GAMICSM: RELATING EDUCATION, CULTURE AND GAMIFICATION - A LINK BETWEEN WORLDS

GamiCSM: Relating education, culture and gamification - a link between worlds

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ABSTRACT

The potential of *gamification* to improve users' *motivation* and *engagement* influenced many researchers and professionals to analyse its effects in educational settings. While some studies focus on adapting game elements according to demographic and behavioural information of the user profile, few of them explore (or even consider) *cultural factors*. These cultural factors play an essential role in our societies' development. Thus, this work proposes and evaluates a representative model to understand better the relationship between cultural factors and gamification within educational domains, namely the *Gamification for Cultural Studies Model (GamiCSM)*. Through a qualitative approach, we map Hofstede's cultural dimensions (i.e., power distance, individualism/collectivism, uncertainty avoidance, masculinity/femininity, long/short-term orientation, and indulgence/restraint) with a Taxonomy of Gamification Elements for Education (TGEEE), a recent model for gamification elements for educational environments. Furthermore, we adapted a survey to evaluate the resultant model with eight domain experts in gamification and education. Based on this evaluation, we are able to propose a starting model, containing some additional refinements and improvements. Thus, the main contributions of this work are: (i) the *first model to relate game elements and cultural dimensions within educational domains* and (ii) a state-of-the-art empirical study intersecting culture, gamification and education.

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CCS CONCEPTS

• **Applied computing** → **Education**; • **Social and professional topics** → *Cultural characteristics.*

KEYWORDS

culture, gamification, model, evaluation

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1 INTRODUCTION

Culture, within the scope of this research, is seen as a structure that ties a group of people. This structure is composed of schemes (patterns) that influence and differentiate the individuals composing the group, allowing these individuals to interact with the environment [20, 42]. A culture can be composed of sub-cultures. For instance, the National Culture is a set of explicit or implicit schemes existent in a country (e.g., in China, people tend to believe that hierarchy should be respected; while in Sweden, people do not think hierarchy should be respected rigidly [21]). Culture plays a major role in education, especially in e-learning systems, since these patterns might influence the way students perceives and acquires their knowledge [42].

Unsurprisingly, then, game-based approaches are also influenced by culture. Even the scheme of "gaming" itself can be considered a subset of a National Culture [28, 44]. Games influence and are influenced by contemporary society behaviours, since they have permeated society, often forming a part of an individuals' routine [4, 11]. An example of how culture has influenced games is the

distinction between sub-genres of role-playing games created in oriental countries, from the ones created in the Occident [3].

These influences also extend to *gamification*, defined as the use of game-like elements outside of a game [6, 27, 43]. Culture is a part of the *context*, which has been shown to be important when designing gamification, to achieve a positive outcome related to motivation or engagement [43]. Context, according to Savard and Mizoguchi [41], can be defined as a set of conditions that encompass an event. This event is held by agents and environments whose interactions enable the given event to occur. An educational context, for example, is composed of a single or group of people (agents) in an environment (or environments) that lead to an event related to learning. This context influences culture as well [41].

In gamification, although there is an increasing awareness about the importance of cultural factors (for instance, the acceptance of certain elements may differ, based on the culture of the users of the system), their exploration represents a current research gap [26]. Recently, Khaleed stated that gamification elements must be aligned with the cultural background of the user, to achieve an optimal effect (e.g., increase performance) [24]. Furthermore, AlMarshedi et al. [2] discuss the importance of cultural aspects in gamification, stating that schemes presented in cultural backgrounds are needed, to understand gamification designs that might influence the users' experience; this is also corroborated by Wellington [52]. In addition, AlMarshedi et al. [2] calls for theoretical work to relate these elements to guide further studies.

Notably in our context, gamification is nowadays considered as increasingly important for educational purposes. Indeed, some studies reported positive effects (e.g., increased motivation and engagement) tied to the use of game elements in educational environments [7]. Nevertheless, other studies present inconclusive results (neither positive nor negative); current thought is that this could be attributed to inappropriate design [51]. Ideally, good designs are those considered to encompass different aspects, such as behavioural profiles and culture of the individual, as well as adaptation to the user needs and characteristics [24, 26, 52].

Adaptation is the process of adapting existing elements to a specific user characteristic, an essential and potentially decisive factor in the effectiveness and adoption of modern e-learning systems [14, 18]. Interestingly, when tied to games and gamification concepts, adaptation has been shown further to increase positive effects on users' motivation [29]. However, past adaptation studies and applications often miss essential aspects that permeate the users' environment, such as culture [26]. This is even more so the case when analysing gamification in adaptive systems, where culture is mostly neglected in the environment design [2, 26, 34].

Thus, this work aims to explore the following research problem: *How can we systematically relate gamification elements and cultural aspects, to use within educational environments?*

To conduct our study, we designed a mixed approach (qualitative research and survey) to create a model that relates gamification elements and cultural dimensions ([21]) for e-learning environments. This work contributes to the fields of:

- Human-Computer Interaction: by providing a first model to adapt culture in gamified learning systems.
- Education: by providing a base model to instructors and educators on the appropriate gamification elements to be used within their culture.
- Gamification: by providing the first empirical model relating culture dimensions and gamification elements for educational environments.

2 BACKGROUND AND RELATED WORKS

This section describes the concepts used in this work, alongside our related works. We explore definitions of culture and describe the model used by Hofstede. As for gamification, we present how these game elements are used within adaptive educational environments and describe a recent taxonomy for gamified educational environments, which is our design starting point. Finally, we present related work to culture and gamification in educational environments.

2.1 Cultural Dimensions

Culture has many definitions. Some authors state that culture is often used to refer to a set of characteristics that are used to differentiate a social group, in a distinct way [1]. Hall [17] described culture as an aggregation of lifestyles, which encompass people behaviour, attitudes and material things. Hofstede [21] defined culture as a set of patterns that differentiate a group of people, but also perceive each member in that group, individually. According to Hofstede [21], the National Culture is a way to distinguish countries based on cultural dimensions. Finally, for education, Savard and Mizoguchi [42] found a relationship between culture and context, where culture is considered a set of schemes that permeate a group of individuals and influence their actions.

Hofstede's model for national culture can be used to compare different cultures and has been thus used heavily both in academia and in industry [40]. This model is composed of six dimensions (Table 1) that can influence students' behaviour and performance, when using e-learning systems, or serious games [9, 21, 47].

As can be seen in Table 1, each dimension shows different aspects of a National Culture. In our context, it is important to include how these dimensions impact upon education, as summarised by Gasparini et al. [14]. For example, in societies with a low PDI degree, education is centred on students, rather than around teachers. Teachers expect students to be pro-active and question or debate everything assertively, in such cultures. While in societies with a higher degree of PDI, education is centred on teachers, and students should respect their authority, above all things in the environment.

2.2 Gamification

Due to its influence on users' motivation, gamification (as the use of game elements outside of games [6]) has been widely used in educational environments [7, 53]. However, to achieve such positive effects, gamification needs to follow good design practices, focusing on a broad range of characteristics of users and their context [27, 39, 49]. As stated by Seaborn and Fels [43], gamification is context-dependent, which means it is essential to understand the environment and its users before implementing it. Whilst gamification aims to promote motivation and engagement in educational settings [7], understanding students (e.g., demographics, behavioural profiles, gaming profiles) is necessary to avoid adverse outcomes

Table 1: Hofstede's Cultural Dimensions for National Culture [21]

Abbr	Dimension	Definition
PDI	Power Distance	Relates to the acceptance of power distribution, e.g., hierarchically in a society. Countries with a higher index of PDI demonstrate that hierarchy is clearly perceived and respected; while a lower degree represents countries where the population questions the authorities, focusing on the equal distribution of power.
MAS	Masculinity × Femininity	Concerns the degree in which societies accept the traditional/conservative model of gender roles, e.g., men in position of power and women in home activities. Countries with a high MAS index are very conservative towards gender roles. Lower degrees of MAS mean that countries are more positive or leaning towards equal rights regarding gender roles.
IDV	Individualism × Collectivism	Considers the degree in which societies are integrated into groups. In countries with a high degree of IDV, individuals tend to be less empathetic and consider themselves first, in their decision-making process and actions. In countries with a low degree of IDV, people tend to think more about the collective instead of themselves (e.g., Japan).
UAI	Uncertainty Avoidance Index	Concerns the degree to which people deal with ambiguity. In countries with a high degree of UAI, people tend to accept only a single "truth", with no space for discussion; while a lower degree means a society that leans more towards discussing different ideas and perspectives.
LTO	Long-term Orientation × Short-term Orientation	Relates to the degree in which societies associate past choices with present / future actions. High degrees of LTO means that a country tends to follow its traditions (more conservative), lower degrees means that a country's decision-making process is either adapted or based on circumstances.
IND	Indulgence × Restraint	Relates to the degree of freedom that a society gives to social norms and how it influences individual aspirations. High degree of indulgence means that a society allows free gratifications of basic human needs and desires; while low IND degree means a society that controls and restrains these gratifications, regulating through social norms.

that may lead to demotivation and undesired behaviours [51]. Many of these variables are not so easy to represent in educational systems, since they deal with abstract knowledge (e.g., culture) which needs to be systematically defined for virtual environments. These variables that permeate the users environment could potentially influence the outcomes achieved by gamification [34]. To overcome such issues, recent work proposed adaptive gamification, which aims to achieve the desired engagement and learning outcomes by adjusting the game-like elements to better suit users' needs and characteristics [35]. Furthermore, adaptation in gamification has been explored through different lenses and approaches, from demographics to gaming profiles [35], using different sets and groups of gaming elements. Nonetheless, these game elements are not so easy to define, and contain different terminologies and concepts in the literature [43]. Furthermore, since context is an important factor for gamification success, it is essential to choose a set of elements that is aligned with the field being explored.

Considering gamification elements for the field of education, the recent work of Toda et al. [48] proposed the Taxonomy of Gamification Elements for Educational Environments (referred as TGEEE; concepts in Table 2). This taxonomy encompasses a dictionary containing 21 gamification elements, their respective synonyms and which dimensions they are referred to. According to the authors, this taxonomy can be used to design and analyse gamified educational systems. It is divided into five dimensions that are linked to specific interactions in educational environments [50]. Besides, authors also claim that these elements were based on literature reviews in the field of education, encompassing many of the elements found in this educational context, and were validated by experts in education.

As can be seen in Table 2, each of the 21 elements were considered useful in educational environments and encompass a set of elements that can be found in the gamification literature. However, few studies in the field of gamification deal with or are concerned with cultural aspects of the user (or student). Whilst context is considered both useful and elusive [26, 35], culture, as part of the context, is potentially easier to detect, and arguably not variable. AlMarshedi et al. [2] created a conceptual framework that explains how social and cultural elements impact behaviour. The authors noted that a way to advance the field is by exploring the users' interaction influences and cultural values. A recent literature review conducted by Klock et al. [26] found only two studies where gamification was used alongside culture (Hofstede's model). In this study [36], the authors explored how Individualism and Collectivism influence the persuasive strategies, finding significant differences between the users' persuasive profiles; e.g., collectivists leaned more towards social interactions.

2.3 Related Research

For related works, it is essential to understand past works that have similar goals to ours, attempting to understand how *culture* can contribute to adapt *gamification in education*. According to theoretical works [2, 24, 52], culture is essential but often neglected in gamification studies, especially in education. However, literature still lacks to find empirical evidence or models to link these concepts [26]. To find and map empirical works, we conducted a systematic

Table 2: TGEEE proposed in Toda et al. [48]

Element	Description	Dimension
Acknowledgement	A feedback that praises the students' specific actions; can be used to define desired behaviours; e.g., increase the number of interactions in a learning system. Some examples and synonyms are badges, medals, trophies.	Performance
Chance	Random events that increase or decrease the odds of certain actions or outcomes. Some examples and synonyms are randomnesses, luck, fortune.	Ecological
Competition	When students compete against each other towards a goal. Some examples and synonyms are Player vs. Player, scoreboards, conflict.	Social
Cooperation	When students collaborate to achieve a goal. Some examples and synonyms are teamwork, co-op missions.	Social
Economy	Transactions within the game, monetising game values and other elements. Some examples and synonyms are markets, transaction, exchange.	Ecological
Imposed Choice	Decisions that the student is obliged to make in to advance in the system. Some examples and synonyms are judgements, forced choices.	Ecological
Level	Hierarchical layers presented in the system, which provide a gradual way for the student to obtain new advantages as they advance. Some examples and synonyms are character levels, skill level.	Performance
Narrative	Order of events where they happen in the system. These are choices influenced by the students' actions. An example would be a karma system, where the students' actions subtly influence the system. *(not to be confused with Imposed Choice).*	Fiction
Novelty	New, updated information presented to the student continuously. Some examples and synonyms are changes, surprises, updates.	Personal
Objectives	Guide the students' in the system. Quantifiable or spatial, from short to long term. Some examples and synonyms are missions, quests, milestones.	Personal
Point	Unit used to measure students' performance or actions. Some examples and synonyms are scores, number of kills, experience points.	Performance
Progression	A way for students to track their position within the content in the system. Some examples and synonyms are progress bars, maps, steps.	Performance
Puzzles	Cognitive challenges within the system that should make a student think. Some examples and synonyms are actual puzzles, cognitive tasks, mysteries.	Personal
Rarity	Rare resources and collectables. Some examples and synonyms are limited items, rarity, collection.	Ecological
Renovation	The capability of a student to redo/restart an action. Some examples and synonyms are extra life, boosts, renewal.	Personal
Reputation	Titles that the students can accumulates within the game. Some examples and synonyms are titles, status, classification.	Social
Sensation	Use of students' senses to create new experiences. Some examples and synonyms are visual stimulation, sound stimulation.	Personal
Social Pressure	Pressure exerted through social interactions with another student(s) in the system. Some examples and synonyms are peer pressure, guilds.	Social
Stats	Visible information used by the student, related to their outcomes within the system. Some examples and synonyms are results, health bar, indicators, data from the game presented to the user.	Personal
Storytelling	Fictional context that can be used in the system. Some examples and synonyms are stories told through animated scenes, audio queues or text queues.	Fiction
Time Pressure	Pressure through time. Some examples and synonyms are countdowns, clock, timer.	Ecological

mapping, using the protocol proposed by Petersen, Vakkalanka and Kuzniarz [38] and Kitchenham et al. [25].

Based on the protocol, we focused on identifying works that relate culture and gamification to the education field, that were published in the past few years. As the term 'gamification' was only relatively recently coined[1], we limited our search for the period 2009-2020. Initially, we defined our search question in a broad sense: *How gamification, culture and education are related in the literature?*. Thus, we searched for works based on the following research string:

> *gamification* **AND** (*cultural* **OR** *culture*) **AND** *education*.

Next, we selected the following databases, based on previous systematic studies on computer science and education fields: ACM Digital Library, ScienceDirect, IEEE Xplore, Scopus, and Taylor and

[1]The term 'gamification' was coined in 2003 by Nick Pelling, a British-born computer programmer and inventor. However, it only hit the mainstream due to Foursquare in 2009.

Francis. In those databases, we chose to search not only within titles, but also abstracts and keywords, to return as many as possible potentially relevant papers. In addition, we defined as our inclusion (i.e., filtering) criteria: (i) papers in the English language; (ii) papers that relate culture with gamification in educational scenarios; (iii) papers that present empirical evidence; (iv) full papers. Any paper that did not match our inclusion criteria would be automatically discarded. Since we adopted the gamification definition presented in Deterding et al. [6], we did not consider papers that dealt with serious games or digital games. These criteria were based on previous systematic mappings [26, 51].

After running our search string, the total number of papers found[2], which represented all three themes (education, gamification and culture) as well as obeyed all filtering criteria, across all four databases, over the considered time period, was quite low (N = 121). Scopus was the one with most papers (N = 105), followed by ScienceDirect (N = 9), and IEEE Xplore (N = 7). We did not find any study on ACM Digital Library, and Taylor and Francis. After further manual screening the papers, we found 2 potential candidates from Scopus, 1 from IEEE Xplore and 1 from ScienceDirect (Total = 4). However, after reading the remaining full papers in their entirety, *none of these studies addressed how culture influences gamified educational applications.*

Table 3: Results from the systematic mapping

Database	Papers found	Candidate papers	Papers selected for analysis
Scopus	105	2	0
ScienceDirect	9	1	0
IEEE Xplore	7	1	0
ACM Digital Library	0	0	0
Taylor and Francis	0	0	0
Total	121	4	0

Table 3 summarises the results from our systematic mapping. We did not find any work that relates culture and gamification in the education field, this might occur due to culture and gamification being a recent field of study, this is evident in the literature review conducted by Klock et al. [26] where the authors found only two papers dealing with culture, in the field of health. Most of the works that were found in our study dealt with culture related to how to use gamification to teach a different language, rather than exploring cultural aspects and factors in the system gamification design.

Thus, the literature review showcased the clear need of a model to offer new ways to adapt gamification, based on cultural factors, as proposed by us in this paper.

3 METHODS AND TOOLS

Due to the abstraction of concepts dealt in this work, we opted to follow a qualitative approach, to design our conceptual model. We opted for a conceptual model since it can optimise and save time in the development process, followed by a survey method and quantitative data to evaluate it. The qualitative approach was chosen due to its method of turning unstructured data into information for the context dealt with [5]. According to [5], qualitative research follows three steps: (i) problem definition and data collection; (ii) analysis; and (iii) making inferences about the studied object.

3.1 Problem definition and data collection

In the first step, we defined the scope of this study as: to create a model of relations between cultural aspects and gamification elements, to be used within educational environments. We explored theoretical research on the fields of gamification and culture, searching for models and data within this subject.

We opted to use Hofstede's dimensions [21] due to being the most widely used model for adaptation, as well as being used within other studies in the field of education [12, 13, 15, 37, 45, 47]. Recent studies also present results on the impact of using Hofstede's model with students' achievement and assessment [13]. A brief relation between this model and games was made but not further explored nor focusing on educational aspects, which allow us to infer some relations within gamification elements [31]. As for the gamification elements, we selected the Taxonomy of Gamification Elements for Educational Environments (TGEEE) [49], since it is the most recent work which summarises gamification elements that are used in educational applications, as well as defining layers that allow us to analyse the gamification within learning systems. Besides, it was evaluated by experts in the field of gamification and education [50].

3.2 Analysis

In the second step, we analysed the data that was found and collected. Initially, we used an *ontological approach* to aid in this phase, consisting of three steps: (i) a conceptual mapping; (ii) semantic mapping; (iii) and ontology definition, based on Ontology 101 [33]. We opted for the ontological engineering approach since ontologies are used to create models about the relation of things [22]. Ontology 101 approach is used to generate ontologies that can be used to extrapolate concepts and relations. Since we did not find any work in the literature to address the concepts presented in this study, we opted to design a generic ontology, which is used to infer a concept to other domains and could be further improved by other studies [16, 22]. In this work, we generalised the relations between cultural dimensions and gamification elements, to be used in educational environments.

Concept maps are used to identify the relations between concepts, and it is used in ontology engineering to visualise the main concepts and their definitions [32]. We used the conceptual mapping to find the Concepts of our model. These maps are also suggested during ontological engineering processes [8, 10, 23, 46]. Semantic mapping is a method used to organise and structure abstract concepts, to visualise possible similar meanings [23]. It is also used in ontology engineering to find concepts and attributes, as well as to support in the transition of existing ontologies to new ones. In this work, we used Semantic mapping to identify possible attributes of the ontology. Finally, the ontology definition happens when we infer the concepts, attributes and relations of the findings in the previous mappings, making abstract concepts into tangible concepts that can be understood and used by computational tools and/or experts in the field [22, 33]. To verify the integrity of our model, we analysed and compared it with another model presented

[2]Complete list of papers presented in https://bit.ly/33jWFm0

in the literature [19] that addresses Hofstede's culture model in general, using a semantic mapping to identify similar concepts between their model and ours. The summary of the second step of our qualitative approach can be seen in Figure 1. We opted for the model proposed by Heimburger [19] since it was the first one to propose the Hofstede's model into a generic ontology.

Figure 1 presents a flowchart of our methods. Initially, we began the conceptual mapping, by identifying relations between concepts, e.g. in Figure 1, *Game is-a Software*. Following, the semantic mapping is used to identify possible attributes of a given concept, e.g. possible Video-game genres are Role-Playing Games (RPG) and Action Games. Finally, the model definition is used to link the concepts and attributes and its possible sub-attributes, e.g. a Game has a Game genre, which is an RPG. In the context of our work, we can say that *Cooperation is-a Gamification element*, or *Collectivism is-a Cultural dimension*.

3.3 Inference

In the third step, we used the knowledge obtained from the previous steps and defined our initial relations between the concepts. In this step, we relate concept and attributes, define the relationship between the dimensions and gamification elements. In other words, we define which elements are suitable to be associated with the given dimension. In this example, *Cooperation and Gamification Element* are concepts, while *is-a* is the relation between them, meaning that one is part of another. After identifying these relations between the elements in Hofstede and TGEEE, we began the semantic mapping step. This step is responsible for structuring the concepts' definitions and analyse how they can relate with other concepts, e.g.: in Hofstede's model, the concept of *Individualism* and *Collectivism* are related with *social interactions* (attribute) where this dimension influences the way people interact within a group; In the TGEEE, *Cooperation* is-an element from the *social dimension* (another concept) that describes collaborative *social interactions* (attribute) towards a goal. After defining the concepts and definitions, we began to design the model relating the concepts between Hofstede's model and TGEEE elements, e.g., Knowing that *Collectivism* has an attribute *social interactions*, and *Cooperation* also has an attribute *social interactions*, we can infer through our model that *Collectivism* can be associated to *Cooperation*. Through this systematisation, we managed to achieve an initial version of our model (Figure 2).

3.4 Evaluation design

To evaluate this model, we opted to conduct a survey, due to its low-cost and reliability [30], followed by analysing the data collected in this survey using descriptive statistics. Using the guidelines proposed in [30], we divided the survey design into three steps: (i) population definition; (ii) question design; and (iii) analysis. For the first step, we defined our population to be experts in gamification, culture or education. To be considered an expert, in this work, we considered people with experience or publications within these three fields. To recruit these participants, we conducted a literature review on the themes of cultural studies or gamification (both applied to education). This literature review consisted of finding venues where we could find experts in two or all the three fields (e.g., the proceedings of the Cultural Aware Tutoring Systems - CATS - conference). Next, we invited those experts through email (convenience sampling). The experts were presented with the model resulting from the qualitative analysis (Figure 2) and each of Hofstede's and TGEEE for consulting during the survey[3].

For the second step, we aimed at identifying instruments that could be used/adapted to evaluate models within our context. Since the study presented in the TGEEE model [49] contained an evaluation that has overall good reliability ($\alpha > 0.7$) we opted to adapt to our context (convenience), measuring the relations between the elements of the model based on descriptions, coverability, and concordance. These items were aligned with what we aimed in this model as well, by evaluating the relations between the concepts and their descriptions to design it. The questions consisted of a sentence formed by "Do you agree with..." followed by the construct we intended to measure. These questions were measured through a Likert scale, from 1 to 5, where 1 being "Totally Disagree", and 5 being "Totally Agree". Additionally, we included open-end questions so the experts could provide insights on how to improve the model, which relations they did not agree and which relations they could include. We also included demographic data from the experts (gender, age, country, field expertise, years working in the field, and if they had worked with education before). For the third step, we used descriptive statistics to analyse and report the data. The complete survey can be found in: https://forms.gle/nnrKmEvRit9BMH5p6.

It is worth to mention that the question design was supervised by experts in both fields, gamification AND culture. Gamification experts (N = 8) had more than 5 years of experience working in the field, culture experts (N = 2) also had a background in the field of HCI, and more than 5 years of experience in the field.

4 RESULTS AND DISCUSSIONS

This section presents our results. Initially, we present the validation of our model, following by the description and final model (Figure 3). In addition, we present the limitations of our work.

4.1 Evaluation

Initially, we contacted 68 researchers from the fields of gamification or culture, however only 8 answered our survey. Our experts are 6 female and 2 male, ranging from 31 to more than 45 years old from five different countries: United States (2), United Kingdom (1), Philippines (1), Japan (1) and Brazil (3). Regarding the fields of expertise, most of our experts came from the field of gamification (6), followed by HCI (2), Computers in education (2), Artificial Intelligence (1), and Software engineering (1), with a minimum of 5 years of experience and maximum of 25. All of the experts worked in the field of education.

Concerning the model evaluation, when asked if the elements are related (concordance) with the dimensional cultures, most of the experts (N = 5) had a positive agreement (above 3 in the Likert scale), meaning that they agreed positively with the way the relations were made, associating the cultural dimensions and gamification elements. Regarding the descriptions presented to make the relation, our model also achieved a positive agreement within half of the

[3]The descriptions presented to the participants can be found in the following link: https://bit.ly/3bInzYw

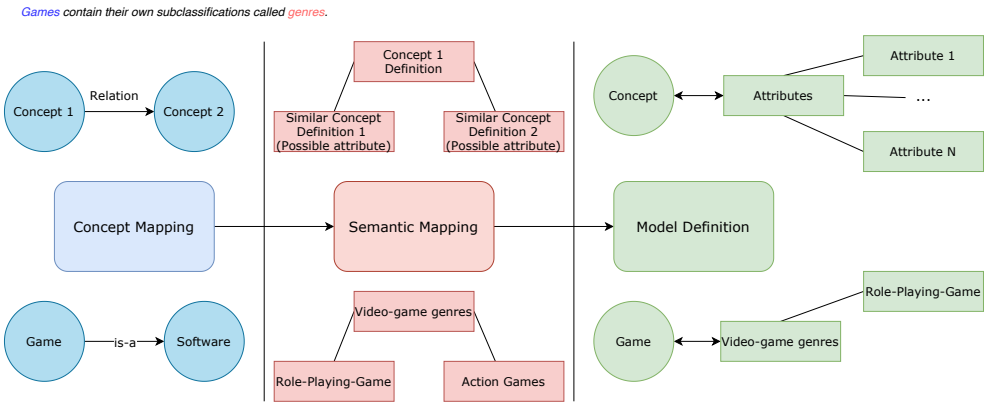

Figure 1: Method flowchart

Hofstede's Dimension	Gamification element
Power Distance	**Rarity, Economy, Reputation**
Power Distance is related to the acceptance on the presence of hierarchical institutions, which can be represented through the game elements **Rarity**, **Economy**, and **Reputation**	
Individualism x Collectivism	**Cooperation, Competition, Social Pressure and Reputation**
Individualism and Collectivism are related to the ties between individuals when they are loose or strong. This dimension can be represented in the following gamification elements **Cooperation**, **Competition**, **Social Pressure** and **Reputation**	
Uncertainty Avoidance	**Point, Level, Stats, Acknowledgement, Progression, Chance**
Uncertainty Avoidance is the extent on how individuals are comfortable in changing the way they live or feel threatened by uncertain and unknown situations. This dimension can be seen through elements that capture the performance of users as **Point**, **Level**, **Stats**, **Acknowledgement**, **Progression** and **Change**	
Masculinity x Femininity	--
Masculinity is related to cultures in which gender roles are clearly distinct while Femininity describes cultures where gender roles overlap. We did not find any elements to represent this dimension.	
Long-Term Orientation x Short-Term Orientation	**Time Pressure**
Long and Short-term orientation are related to planning for future in advance and/or present oriented actions. The element related to this dimension is **Time Pressure**.	
Indulgence x Restraining	**Imposed Choice, Objective, Sensation, Puzzle, Renovation, Novelty**
Indulgence x Restraining are related to the regulation through social norms or allowance of basic drives related to fun. The elements related to this dimension are **Imposed Choice**, **Objective**, **Sensation**, **Puzzle**, **Renovation** and **Novelty**.	

Figure 2: Result of the qualitative approach that was presented to the experts

experts (N = 4), with one expert stating that some elements were missing in the descriptions (e.g. no elements presented in MAS dimension). Finally, when asked if the elements are well-aligned with all the dimensions, we had half of the experts (N = 4) towards a disagreement, with three experts towards an agreement. In this variable, we noticed a discrepancy between the opinions when analysing the comments of the experts, and we tried to deal with all the disagreements to propose the model seen in Figure 3.

We also asked which of the dimensions relations they disagreed with. According to their responses, IND and LTO were the relations they disagree the most (N = 3 experts), followed by UAI and MAS (N = 2 experts), and PDI (N = 1 expert). Based on their comments, we removed some of the elements (e.g., Novelty, Renovation and Puzzle from IND) and added new ones (e.g., Narrative, Objective and Progression to LTO). All of the experts agreed with the relationship formed between IDV and social gamification elements, so no changes were made in these dimensions. No details were given on the disagreement on the PDI dimension so that this dimension did not change.

In addition, we asked which elements the experts did not convince them within the relations. According to one expert, the taxonomy might have missed some elements (e.g., customisation) that could be associated with genders, while other expert stated that "Time Pressure" might not be a good element to represent LTO, but Long-term and Short-term "Objectives" would be more appropriate alongside "Progression". Finally, one final expert stated they disagreed with the following elements Competition, Cooperation, Narrative, Novelty, Objectives, Puzzles, Renovation, Social Pressure, Storytelling, but did not provide enough details on this choice. Some other suggestions were made to improve the model as: including Narrative in LTO; including Competition, Cooperation, Social Pressure, and Storytelling as a way to measure the MAS index; Remove Puzzles, Novelty and Renovation from IND.

Considering the overall acceptance of the model, We had mixed views where 1 expert totally disagreed, 3 experts were towards a disagreement, 2 experts were towards an agreement, and 2 experts totally agreed with. In other words, half of the experts were in the disagreement spectrum and half in the agreement spectrum, with more experts totally agreeing with the model as it is (N = 2) than disagreeing (N = 1). In other words, experts identified and suggested modifications on the model, to be presented and used. Overall, based on all responses, we can observe that our model received positive feedback and acceptance. Even though we could not map Storytelling and Narrative elements properly, experts suggested that they could be aligned with LTO (Narrative) and MAS (Storytelling) indexes, which is worth to consider in future interactions. According to the acceptance of the relations, IDV did not receive any criticism which aligns with previous studies that are concerned with culture and social elements in gamification [2].

4.2 Model

After evaluating the model reached in our qualitative approach, we achieved the model presented in Figure 3. In this model, we relate each dimension presented in Hofstede's culture model to a gamification element presented in TGEEE.

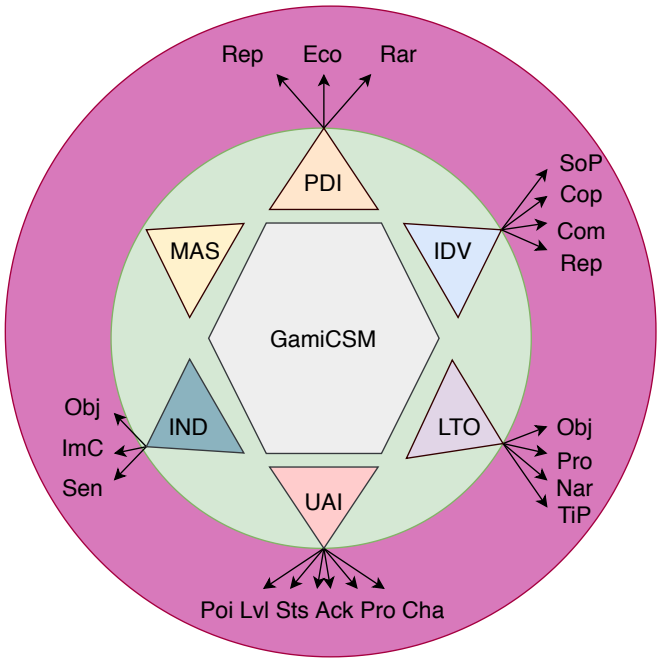

Figure 3: GamiCSM. In green: Cultural dimensions. In pink: gamification elements

As we can observe in Figure 2, Power Distance (PDI) was related to elements concerned with the notion of power, in this case, Rarity (Rar) deals with rare resources and Economy (Eco) is tied to the market and transactions within a system, both are ecological elements that deals with the environment they are implemented in and provide a sense of power to the user. When tied with Reputation (Rep), which represents social hierarchies, they can be used in systems where the Power Distance Index is high and should be avoided where this index is low.

Following, IDV dimension was related to social gamification elements, since both are concerned with social interactions. Cooperation (Cop) and Social Pressure (SoP) should be related with Collectivism (low IND), since in Collectivist societies people tend to be more empathetic and think in the group as a whole, Cooperation features in educational systems might be appealing, while Social Pressure might engage people to collaborate. Concerned with Individualistic societies, where individuals prioritise their needs over others, Reputation (Rep) and Competition (Com) might work better, since these individuals do not consider the needs of the group as a priority.

Concerned with UAI, this dimension is related to change in individuals' actions or feel threatened to embrace unknown situations. We though Performance elements (Point - Poi, Level - Lvl, Stats - Sts, Acknowledgement - Ack, and Progression - Pro) might be suitable for groups that are not comfortable with changes, where they can track and measure every action (low UAI). When adding the Chance element (Cha), this adds a random and uncertainty to the events of a system, which might be suitable for people that prefer changes (high UAI).

We did not match any elements with MAS dimension due to its abstraction, which might be covered in the future, more details in the Limitations section. Considering the short-term and long-term orientation (LTO), as this dimension is related to planning actions or the direct response to present situations, the elements that are best suited to deal with it are Objectives (Obj), alongside Progression (Pro), Narrative (Nar), and Time Pressure (TiP), as it enforces the necessity to plot a strategy in a determined amount of time. However, Time Pressure might not be suited to users accustomed to long term strategies and reasoning.

Finally, indulgent cultures (IND) place more importance on the freedom of speech and personal control, while these same characteristics might be considered inappropriate and unnatural in restrained cultures. As such, the elements of Imposed Choice (ImC), and Objective (Obj) might be better used on restrained cultures, and Sensation (Sen) tend to be better used on indulgent cultures. This dimension can also be tied to the Power Distance dimension, as usually, cultures with high Power Distance index are usually more restrained and vice versa.

4.3 Limitations

Here, it is important, firstly, to note some limitations of the systematic mapping used in our literature review: (i) whilst we conduct the search based on more than just titles, we did not do any search in the full body of the paper; this decision was made due to considering that, if the paper was focused on the areas of interest, these should, normally, have appeared in the triad title, keywords, abstract; (ii) we did not analyse the papers concerned with teaching languages; this we considered to be beyond the scope of this work; (iii) we also did not consider papers on serious games; this was due to the fact that we adopted the concept of 'gamification' as seen in the work of Deterding et al. [6]; (iv) we only considered papers in English language, which might infer a bias to our analysis since cultural studies can be found in other languages. We believe this can be further explored in future studies.

Furthermore, some limitations of our evaluation work are worth to be mentioned. First, we did not apply a pilot study to verify the integrity of our instrument. However, there were HCI experts involved in the development and the survey received feedback from two experts on the field of HCI that had previous experience (more than 5 years), and also worked previously with surveys. Another limitation was that we did not manage to get answers from any expert from the field of culture in our evaluation, which might limit our analysis to the fields of gamification and education. The experts that participated in the development of the survey could not participate in the evaluation due to conflict of interests. The number of experts that evaluated this model was relatively low. Although we have contacted 68 experts, we only obtained 8 responses, which may limit somewhat the generalisation power of our work. However, as they all are experts in education, and as most

expert-based evaluations are less concerned with the numbers, and instead are interested in the in-depth focus of their feedback, our findings may be considered promising.

Finally, considering our model, we find the concepts of MAS too abstract to be aligned with the gamification elements of TGEEE. Although some experts did provide some suggestions, we found that these elements were still too simple to represent the concepts in these dimensions. This was also agreed by the experts of culture and HCI that supervised the conception and design of the model.

5 CONCLUSIONS AND FUTURE WORK

In this work, we proposed to explore the research gap on how to relate gamification and culture. We conducted a mixed approach study, aiming at creating a model to relate cultural dimensions and gamification elements for educational environments. Through our evaluation, it is perceived that we received mixed comments on the model on its current state, although some improvements can be made in future versions to improve it. Our main contribution is the first model to relate these two worlds that can potentially help gamification designers and educators to understand how culture can affect and is related to gamification outcomes in education. This may allow different kinds of adaptation strategies tied not only to students' demographics and behavioural profiles but also their countries. We also contribute by providing a protocol for systematic studies that can be replicated to include other terms to explore gamification, education and culture. Thus, through the execution of this study we can identify topics that could be worth exploring in future research:

- Validate the model through data-driven studies: by analysing the preferences of gamification elements and matching them with the dimension they are associated with, e.g. in countries with a high PDI, people might prefer elements as Reputation and Economy;
- Expand the selection of gamification elements to other fields;
- Provide empirical evidence through experiments on cross-cultural studies, to verify the integrity of the model to different cultures.

It is worth to emphasise that this model is part of a greater project that aims to explore ways to personalise gamification through different constructs. Culture is included within those constructs and must be tied to other aspects as contexts, demographics (e.g., gender and age), and behavioural profiles, aiming to promote the best immersive learning experience for students. Through this model, we believe we can provide some initial contribution to the field of gamification, culture, and education. The results contained in this study can be used to support the decision-making process of designers and educators to develop educational systems based on culture, and the model can also be used to explore and analyse how different cultures influence gamification elements and how it can influence students on these cultures as well (e.g., verify if their preferences match their cultural indexes based on Hofstede's original scores).

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REFERENCES

[1] El-Sayed Abou-Zeid. 2005. A culturally aware model of inter-organizational knowledge transfer. *Knowledge Management Research & Practice* 3, 3 (aug 2005), 146–155. https://doi.org/10.1057/palgrave.kmrp.8500064

[2] Alaa AlMarshedi, Vanissa Wanick, and Gary B. Wills. 2016. Gamification and Behaviour. In *Gamification*. 3–18. https://doi.org/10.1007/978-3-319-45557-0

[3] Kerry G Blasingim. 2006. HERO MYTHS IN JAPANESE ROLE-PLAYING GAMES. http://rave.ohiolink.edu/etdc/view?acc{_}num=bgsu1147711469

[4] Garry Chick. 1998. Games in culture revisited: A replication and extension of Roberts, Arth, and Bush (1959). *Cross-Cultural Research* 32, 2 (may 1998), 185–206. https://doi.org/10.1177/106939719803200204

[5] Juliet Corbin and Anselm Strauss. 2014. *Basics of qualitative research: Techniques and procedures for developing grounded theory*. Sage publications.

[6] Sebastian Deterding, Miguel Sicart, Lennart Nacke, Kenton O'Hara, and Dan Dixon. 2011. From Game Design Elements to Gamefulness: Defining "Gamification". *Proceedings of the 2011 annual conference extended abstracts on Human factors in computing systems - CHI EA '11* (2011), 2425. https://doi.org/10.1145/1979742.1979575 arXiv:11/09 [ACM 978-1-4503-0816-8]

[7] Christo Dichev and Darina Dicheva. 2017. Gamifying education: what is known, what is believed and what remains uncertain: a critical review. , 9 pages. https://doi.org/10.1186/s41239-017-0042-5

[8] Julio Cesar dos Reis, Cédric Pruski, Marcos Da Silveira, and Chantal Reynaud-Delaître. 2014. Understanding semantic mapping evolution by observing changes in biomedical ontologies. *Journal of Biomedical Informatics* 47 (feb 2014), 71–82. https://doi.org/10.1016/j.jbi.2013.09.006

[9] Ian Dunwell, Petros Lameras, Craig Stewart, Pangiotis Petridis, Sylvester Arnab, Maurice Hendrix, Sara de Freitas, Mark Gaved, Björn Schuller, and Lucas Paletta. 2013. Developing a digital game to support cultural learning amongst immigrants. In *In Proc. 1st International Workshop on Intelligent Digital Games for Empowerment and Inclusion (IDGEI 2013) in conjunction with the 8th Foundations of Digital Games*.

[10] Mohamed El-Mekawy and Anders Östman. 2010. Semantic mapping: an ontology engineering method for integrating building models in IFC and CityGML. In *3rd ISDE DIGITAL EARTH SUMMIT, 12-14 June,*.

[11] Entertainment Software Association. 2019. *Essential Facts About the Computer and Video Games Industry*. Technical Report. ESA. https://www.theesa.com/wp-content/uploads/2019/05/ESA_Essential_facts_2019_final.pdf

[12] Zheng Fang, Xianxuan Xu, Leslie W Grant, James H Stronge, and Thomas J Ward. 2016. National culture, creativity, and productivity: What's the relationship with student achievement? *Creativity Research Journal* 28, 4 (2016), 395–406.

[13] Zheng Fang, Xianxuan Xu, Leslie W. Grant, James H. Stronge, and Thomas J. Ward. 2016. National Culture, Creativity, and Productivity: What's the Relationship with Student Achievement? *Creativity Research Journal* 28, 4 (2016), 395–406. https://doi.org/10.1080/10400419.2016.1229976 arXiv:https://doi.org/10.1080/10400419.2016.1229976

[14] Isabela Gasparini, Avanilde Kemczinski, Marcelo Soares Pimenta, and José Palazzo Moreira de Oliveira. 2011. Modelo do usuário sensível ao contexto cultural em um sistema e-learning adaptativo. *Informática na educação: teoria & prática* 14, 1 (2011), 123–135. https://doi.org/10.22456/1982-1654.21974

[15] Isabela Gasparini, Marcelo S. Pimenta, and José Palazzo M. De Oliveira. 2011. Vive La Différence! A Survey of Cultural-Aware Issues in HCI. In *Proceedings of the 10th Brazilian Symposium on Human Factors in Computing Systems and the 5th Latin American Conference on Human-Computer Interaction* (Porto de Galinhas, Pernambuco, Brazil) *(IHC+CLIHC '11)*. Brazilian Computer Society, Porto Alegre, BRA, 13–22.

[16] Nicola Guarino. 1997. Understanding, building and using ontologies. *International Journal of Human-Computer Studies* 46, 2-3 (1997), 293–310.

[17] Edward Twitchell Hall. 1989. *Beyond culture*. Anchor.

[18] Marc Hassenzahl and Noam Tractinsky. 2006. User experience - a research agenda. *Behaviour & Information Technology* 25, 2 (2006), 91–97. https://doi.org/10.1080/01449290500330331

[19] Anneli Heimbürger. 2008. When Cultures Meet: Modelling Cross-Cultural Knowledge Spaces. In *Proceedings of the 2008 Conference on Information Modelling and Knowledge Bases XIX*. IOS Press, NLD, 314–321.

[20] Geert Hofstede. 1984. *Culture's consequences: International differences in work-related values*. Vol. 5. sage.

[21] Geert Hofstede. 2011. Dimensionalizing cultures: The Hofstede model in context. *Online readings in psychology and culture* 2, 1 (2011), 8.

[22] Seiji Isotani and Ig Ibert Bittencourt. 2015. *Dados Abertos Conectados*. Novatec. 175 pages. https://doi.org/10.13140/RG.2.1.4355.6329 arXiv:arXiv:1011.1669v3

[23] Dale D Johnson, Susan D Pittelman, and Joan E Heimlich. 1986. Semantic mapping. *The Reading Teacher* 39, 8 (1986), 778–783.

[24] Rilla Khaled. 2015. Gamification and Culture. *The gameful world: Approaches, issues, applications* (2015), 301.

[25] Barbara Kitchenham, O Pearl Brereton, David Budgen, Mark Turner, John Bailey, and Stephen Linkman. 2009. Systematic literature reviews in software engineering - A systematic literature review. , 7–15 pages. https://doi.org/10.1016/j.infsof.2008.09.009

[26] Ana Carolina Tomé Klock, Isabela Gasparini, Marcelo Soares Pimenta, and Juho Hamari. 2020. Tailored gamification: A review of literature. *International Journal of Human-Computer Studies* (jun 2020), 102495. https://doi.org/10.1016/J.IJHCS.2020.102495

[27] Jonna Koivisto and Juho Hamari. 2019. The rise of motivational information systems: A review of gamification research. , 191–210 pages. https://doi.org/10.1016/j.ijinfomgt.2018.10.013

[28] Sybille Lammes. 2007. Approaching game-studies: towards a reflexive methodology of games as situated cultures.. In *DiGRA Conference*.

[29] Elise Lavoue, Baptiste Monterrat, Michel Desmarais, and Sebastien George. 2018. Adaptive Gamification for Learning Environments. , 16–28 pages. https://doi.org/10.1109/TLT.2018.2823710

[30] Jonathan Lazar, Jinjuan Heidi Feng, and Harry Hochheiser. 2017. *Research methods in human-computer interaction*. Morgan Kaufmann.

[31] C. J. Meershoek, R. Kortmann, S. A. Meijer, E. Subrahmanian, and A. Verbraeck. 2014. The culture driven game design method: Adapting serious games to the players' culture. In *Perspectives on Culture and Agent-Based Simulations: Integrating Cultures*. Springer International Publishing, Cham, 231–249. https://doi.org/10.1007/978-3-319-01952-9_13

[32] Joseph D Novak. 1990. Concept mapping: A useful tool for science education. *Journal of research in science teaching* 27, 10 (1990), 937–949.

[33] Natalya F Noy, Deborah L McGuinness, and Others. 2001. Ontology development 101: A guide to creating your first ontology.

[34] Wilk Oliveira and Ig Ibert Bittencourt. 2019. *Tailored Gamification to Educational Technologies*. Springer Singapore, Singapore. https://doi.org/10.1007/978-981-32-9812-5

[35] Rita Orji, Gustavo F Tondello, and Lennart E Nacke. 2018. Personalizing Persuasive Strategies in Gameful Systems to Gamification User Types. 1–14. https://doi.org/10.1145/3173574.3174009

[36] Kiemute Oyibo, Rita Orji, and Julita Vassileva. 2017. The influence of culture in the effect of age and gender on social influence in persuasive technology. In *Adjunct publication of the 25th conference on user modeling, adaptation and personalization*. 47–52.

[37] Yu-Shu Peng and Shing-Shiuan Lin. 2009. National culture, economic development, population growth and environmental performance: The mediating role of education. *Journal of Business Ethics* 90, 2 (2009), 203–219.

[38] Kai Petersen, Sairam Vakkalanka, and Ludwik Kuzniarz. 2015. Guidelines for conducting systematic mapping studies in software engineering: An update. In *Information and Software Technology*, Vol. 64. Elsevier, 1–18. https://doi.org/10.1016/j.infsof.2015.03.007 arXiv:arXiv:1011.1669v3

[39] Luiz Rodrigues, Wilk Oliveira, Armando Toda, Paula Palomino, and Seiji Isotani. 2019. Thinking Inside the Box: How to Tailor Gamified Educational Systems Based on Learning Activities Types. In *Brazilian Symposium on Computers in Education (Simpósio Brasileiro de Informática na Educação-SBIE)*, Vol. 30. 823.

[40] Luciana Salgado, Roberto Pereira, and Isabela Gasparini. 2015. Cultural issues in HCI: Challenges and opportunities. In *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, Vol. 9169. Springer, Cham, 60–70. https://doi.org/10.1007/978-3-319-20901-2_6

[41] Isabelle Savard, Jacqueline Bourdeau, and Gilbert Paquette. 2020. Considering cultural variables in the instructional design process: A knowledge-based advisor system. *Computers and Education* 145 (feb 2020), 103722. https://doi.org/10.1016/j.compedu.2019.103722

[42] Isabelle Savard and Riichiro Mizoguchi. 2019. Context or culture: what is the difference? , 23 pages. https://doi.org/10.1186/s41039-019-0112-5

[43] Katie Seaborn and Deborah I. Fels. 2014. Gamification in Theory and Action: A Survey. *Internatoinal Journal of Human-Computer Studies* 74 (2014), 14–31. https://doi.org/10.1016/j.ijhcs.2014.09.006

[44] Shannon Blake Skelton. 2008. Gaming as Culture: Essays on Reality, Identity and Experience in Fantasy Games. *The Journal of Popular Culture* 41, 1 (2008), 178–180. https://doi.org/10.1111/j.1540-5931.2008.00497_12.x

[45] Filomachi Spathopoulou, Stavros Papakonstantinidis, et al. 2017. Culture as a parameter in assessing students performance. *Humanities and Social Sciences Letters* 5, 3 (2017), 72–78.

[46] Rodrigo Rizzi Starr and José Maria Parente De Oliveira. 2013. Concept maps as the first step in an ontology construction method. *Information Systems* 38, 5 (jul 2013), 771–783. https://doi.org/10.1016/j.is.2012.05.010

[47] Craig Stewart. 2012. A cultural education model: design and implementation of adaptive multimedia interfaces in eLearning. (2012). http://eprints.nottingham.ac.uk/12587/

[48] Armando Toda, Wilk Oliveira, Ana Klock, Paula Palomino, Marcelo Pimenta, Ig Bittencourt, Lei Shi, Isabela Gasparini, Seiji Isotani, and Alexandra Cristea. 2019. A taxonomy of game elements for gamification in educational contexts: Proposal and evaluation. In *2019 IEEE 19th International Conference on Advanced Learning Technologies (ICALT)*, Vol. 2161. IEEE, 84–88.

[49] Armando M. Toda, Wilk Oliveira, Lei Shi, Ig Bittencourt, Seiji Isotani, and Alexandra Cristea. 2019. Planning Gamification Strategies based on User Characteristics and DM : A Gender-based Case Study. In *Proceedings of the Educational Data Mining 2019 conference*. Montréal, 438 – 443. arXiv:1905.09146 http://arxiv.org/abs/1905.09146

[50] Armando M Toda, Paula T Palomino, Wilk Oliveira, Luiz Rodrigues, Ana C T Klock, Isabela Gasparini, Alexandra I Cristea, and Seiji Isotani. 2019. How to Gamify Learning Systems? An Experience Report using the Design Sprint Method and a Taxonomy for Gamification Elements in Education. *Journal of Educational Technology & Society* 22, 3 (2019), 47–60.

[51] Armando M. Toda, Pedro H.D. D. Valle, and Seiji Isotani. 2018. The Dark Side of Gamification: An Overview of Negative Effects of Gamification in Education. In *Communications in Computer and Information Science*, Vol. 832. Springer, Cham, 143–156. https://doi.org/10.1007/978-3-319-97934-2_9

[52] Robert Wellington. 2015. Context to Culture for Gamification HCI Requirements: Familiarity and Enculturement. In *Gamification in Education and Business*. Springer International Publishing, Cham, 151–163. https://doi.org/10.1007/978-3-319-10208-5_8

[53] Zamzami Zainuddin, Samuel Kai Wah Chu, Muhammad Shujahat, and Corinne Jacqueline Perera. 2020. The impact of gamification on learning and instruction: A systematic review of empirical evidence. *Educational Research Review* 30 (jun 2020), 100326. https://doi.org/10.1016/j.edurev.2020.100326

ANNEX

F

A PROCESS FOR GENERATING GAMIFIED DESIGNS FOR TEACHING - IN BRAZILIAN PORTUGUESE

Um processo para geração de *designs* gamificados para o ensino

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Resumo

A gamificação no ensino no ensino vem se consolidando e obtendo resultados positivos nos últimos anos. Este processo consiste no uso de elementos de jogos fora de seu escopo original, com a intenção de melhorar a motivação de um indivíduo perante uma atividade desempenhada. No entanto, alguns estudos recentes denotam a dificuldade de mesurar com precisão os efeitos positivos da gamificação, uma vez que se nota a necessidade de metodologias sistemáticas e a análise individual dos elementos empregados. Baseando-se nesta premissa, este projeto visa demonstrar um processo para geração de designs gamificados para aplicação no ensino. O processo recebe como *input* um plano de aula e/ou ementas da disciplina e, com auxílio de um especialista, são geradas atividades gamificadas (como *outputs*) para serem utilizadas em conjunto com as aulas presenciais, objetivando tornar o processo de ensino mais prazeroso para os alunos. Em sua primeira versão, aplicada no ensino de programação, o processo encontrou resultados significativos, porém ainda necessitando de refinamentos, uma vez que grande parte dos alunos não se sentiram satisfeitos. A segunda versão do processo foi aplicada em uma disciplina de bioquímica, de um curso de Biotecnologia, alcançando resultados positivos em relação a motivação dos alunos. Acredita-se que um dos diferenciais deste processo é a preocupação com os riscos associados ao processo de gamificação, que muitas vezes não são considerados quando são realizados experimentos gamificados. Além disso, a versão atual do processo permite uma maior adaptabilidade por parte do docente, e considera a utilização de perfis de jogador para geração dos *designs* gamificados.

Introdução e Referencial Teórico

A área de ensino vem passando por diversas modificações nos últimos anos, principalmente por conta da inserção de novas tecnologias para apoiar os processos existentes. Dentre estas tecnologias, pode-se citar o processo de gamificação, que vem sendo amplamente difundido e utilizado nos últimos anos em diversas áreas (Lee; Hammer, 2011).

A gamificação é definida como o uso de elem1entos de jogos fora de seu escopo original, com um propósito (Deterding et al., 2011). Este propósito geralmente está associado a melhorar a motivação de um indivíduo perante uma atividade realizada, como a motivação para aprender ou para utilizar um serviço e/ou aplicação (Huotari; Hamari, 2012; Kapp, 2012).

A partir de estudos realizados por Borges et al. (2013) e Dicheva et al. (2015), observa-se que a gamificação vem contribuindo positivamente para a área de ensino, seja por aplicações computacionais ou através de metodologias de ensino. Entretanto, estudos recentes apontaram a necessidade de processos sistemáticos e de formas de mesurar os efeitos da gamificação, quanto aos elementos empregados (Dicheva et al., 2015; Mora et al., 2015). Além disso, outro ponto importante e debatido é que a maioria dos processos existentes não se preocupam com os riscos associados ao processo de gamificação, tais como o declínio dos efeitos motivacionais, a privacidade dos discentes, a qualidade da tarefa e a trapaça (Thiebes; Lins; Basten, 2014).

Utilizando como base estas premissas, este projeto visa desenvolver um processo para gerar designs gamificados para uso em sala de aula, apresentando alguns estudos de caso para apoiar a adoção deste processo. Este artigo aborda as etapas do processo e uma breve descrição sobre os estudos de caso.

Processo para geração de *designs* gamificados

O processo proposto divide-se em 4 etapas, sendo Definição do conteúdo, Definição de Elementos de Jogos, Implantação e Validação. O docente pode, a partir de um plano de aula e/ou ementa como entrada, gerar um design gamificado para ser aplicado em conjunto com a sua prática tradicional de ensino, podendo gamificar desde uma atividade, até uma aula inteira ou um curso de longa duração (Figura 1).

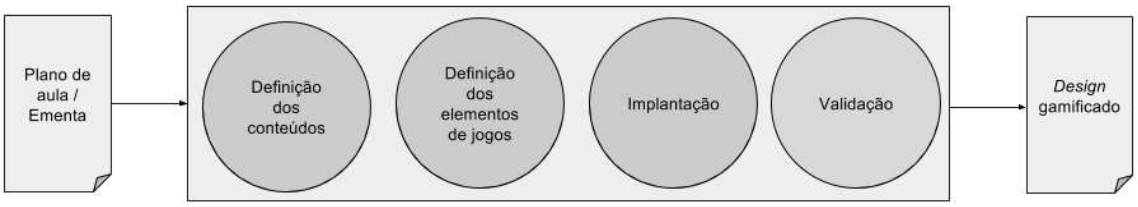

Figura 1: Fluxo do processo

A Figura 1 apresenta o fluxo resumido do processo e suas respectivas fases. A primeira fase consiste na definição e descrição dos conteúdos a serem abordados, objetiva-se analisar o plano/ementa com o intuito de gerar um mapa conceitual. Neste mapa, recomenda-se considerar o conteúdo a ser ministrado assim como as atividades associadas a ele. Após a geração do mapa, inicia-se a fase de Definição dos Elementos de Jogos, ou seja, as dinâmicas que serão utilizadas. Para auxiliar nessa seleção, foi gerado um conjunto de elementos, baseado em revisões sistemáticas encontradas (Borges et al., 2013; Dicheva et al., 2015; Hamari; Koivisto; Sarsa, 2014) divididos em 2 grupos: Elementos de Propriedade e *Feedback*.

O primeiro grupo consiste de características da atividade a ser desempenhada, contendo 12 elementos, sendo: Cooperação, Renovação, Narrativa, Competição, Pressão, Economia, Decisões, Atividades Cognitivas, Oportunidades, Aleatoriedade, Segredos e Novidade. Já o segundo grupo, contém 6 elementos: Reputação, Pontos, Conquistas, Troféus, Níveis e Progresso.

Dentre os elementos de Propriedade, Cooperação e Competição consistem de atividades onde haja a integração ou conflito entre 2 ou mais estudantes; Renovação é a característica relacionada a reutilização de uma atividade ou tarefa; Narrativa consiste na inserção de um contexto imaginário com o intuito de contextualizar a atividade; Pressão é um elemento para exercer uma intenção sobre um indivíduo, podendo ser dividida em temporal (Tempo como influencia) ou social (Outros indivíduos como influência);

Economia é a inserção de elementos de mercado (troca e venda); Decisão é a característica que permite ao(s) discente(s) uma escolha; Atividades cognitivas são associadas a atividades que influenciam em aspectos cognitivos do estudante, como resolução de problemas; Oportunidades estão relacionadas a equidade dos recursos e/ou chances disponibilizados aos discentes durante a atividade realizada; Segredos consistem de recursos, ou outros elementos, desconhecidos pelos estudantes; Novidade é a característica responsável pela inovação e pela inserção de novos recursos, ou elementos; Por fim, a Aleatoriedade consiste de uma variável, recurso ou elemento que não pode ser controlado. Já os elementos de Feedback consistem de motivadores extrínsecos, cedidos como retorno pelas atividades desempenhadas, associando-os aos elementos de Propriedade.

A primeira versão do processo, em sua fase inicial, foi aplicada em uma turma de 40 alunos da disciplina de Linguagens e Técnicas de Programação, com duração de 1 semestre. A experiência, de forma geral, foi considerada positiva, no entanto houveram alguns *feedbacks* negativos, e em alguns casos, a gamificação atrapalhou o processo de aprendizagem de alguns (6) alunos (Mesquita et al., 2013, 2014). O *design* gamificado gerado utilizou apenas elementos de Feedback (Pontos, Reputação, Níveis e Progresso) sem considerar os elementos de Propriedade das atividades.

A versão atual do processo, com elementos de Feedback e Propriedade, foi aplicada em uma turma de Bioquímica, do curso de Biotecnologia, consistindo de 24 alunos no período de 1 semestre. O *design* gamificado gerado foi, de modo geral, bem aceito pelos discentes da disciplina, utilizando os seguintes elementos de Feedback e Propriedade: Pressão temporal, Oportunidades, Atividades Cognitivas, Competição, Níveis, Progresso, Cooperação, Aleatoriedade, Pontos e Economia (Silva; Toda; Xavier, 2016).

Em relação aos riscos do processo de gamificação, acredita-se que a versão atual do processo aborda os efeitos motivacionais declinantes, que consistem da percepção da gamificação como um processo evolutivo, e a trapaça, que é associada a má implantação do processo (Thiebes; Lins; Basten, 2014). No entanto, ainda não foi realizada uma avaliação formal para correlacionar estes riscos com os resultados encontrados.

Conclusão e Trabalhos Futuros

Este artigo apresentou um processo para geração de *designs* gamificados para o ensino, apontando estudos de caso que relatam o sucesso da implantação destes *designs*. Acredita-se que este processo possa favorecer positivamente o processo de ensino, uma vez que os estudos de caso demonstram que ele independe de conteúdo.

Como trabalho em andamento, o processo está sendo aprimorado (passando por uma reformulação), de modo que beneficie e agilize as fases de Definição de Conteúdos e de Elementos de jogos, utilizando como base processos ágeis. Outro trabalho em andamento consiste na elaboração de avaliações e/ou designs experimentais para correlacionar as variáveis encontradas em uma sala de aula com os riscos da gamificação, de modo a medir de forma quantitativa, a eficiência do processo em evitar estes aspectos.

Por fim, como trabalho futuro, pretende-se desenvolver um sistema que automatize o processo, com base em um histórico de estudos de caso, para gerar os *designs* gamificados, assim como auxiliar os docentes no processo experimental.

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Referências bibliográficas

BORGES, S. DE S. et al. Gamificação Aplicada à Educação : Um Mapeamento Sistemático. **Anais do Simpósio Brasileiro de Informática Educativa**, n. July 2015, p. 234–243, 22 nov. 2013.

DETERDING, S. et al. From Game Design Elements to Gamefulness: Defining "Gamification". **Proceedings of the 2011 annual conference extended abstracts on Human factors in computing systems - CHI EA '11**, p. 2425, 2011.

DICHEVA, D. et al. Gamification in Education : A Systematic Mapping Study. **Educational Technology & Society**, v. 18, n. 3, p. 1–14, 2015.

HAMARI, J.; KOIVISTO, J.; SARSA, H. Does Gamification Work? - A Literature Review of Empirical Studies on Gamification. **2014 47th Hawaii International Conference on System Sciences**, 2014.

HUOTARI, K.; HAMARI, J. Defining gamification: a service marketing perspective. **Proceeding of the 16th International Academic MindTrek Conference**, p. 17–22, 2012.

KAPP, K. M. The Gamification of Learning and Instruction: Game-based Methods and Strategies for Training and Education. 1 maio 2012.

LEE, J. J.; HAMMER, J. Gamification in Education: What, How, Why Bother? **Academic Exchange Quarterly**, v. 15, p. 1–5, 2011.

MESQUITA, M. et al. Utilizing Gamification concepts tied with Social Networks to support students in programming classes. **Proceedings of the XV Simpósio Internacional de Informática Educativa**, p. 127–132, 2013.

MESQUITA, M. A. A. et al. **Utilizing gamification with social network to aid students in programming languages lessons in higher education IT courses (abstract only)** Proceedings of the 45th ACM technical symposium on Computer science education - SIGCSE '14. New York, USA: ACM Press, 5 mar. 2014.

MORA, A. et al. **A Literature Review of Gamification Design Frameworks**2015 7th International Conference on Games and Virtual Worlds for Serious Applications (VS-Games). set. 2015

SILVA, Y. R. O.; TODA, A. M.; XAVIER, L. **TEACHING BIOCHEMISTRY USING EDUCATIONAL GAMES AND GAMIFICATION STRATEGIES** Anais da 45a Reunião Anual da Sociedade Brasileira de Bioquímica e Biologia Molecular. Natal: 2016

THIEBES, S.; LINS, S.; BASTEN, D. GAMIFYING INFORMATION SYSTEMS - A SYNTHESIS OF GAMIFICATION MECHANICS AND DYNAMICS. **ECIS 2014 Proceedings**, 2014.

ANNEX

G

A GAMIFICATION PROCESS IN HIGHER EDUCATION: PERSPECTIVES FROM A BIOCHEMISTRY MODULE - IN BRAZILIAN PORTUGUESE

Um processo de Gamificação para o ensino superior: Experiências em um módulo de Bioquímica

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Abstract. *Gamification is gaining prominence in the past few years due to various researches in many areas achieving positive results. In education, this concept has been widespread, yet it still lacks a systemic process to its implementation. This paper presents a conceptual model of a gamification process to be applied within higher education lessons. The main results of this work is a gamified process validated during the gamification of a biochemistry lesson in a Biotechnology course. To validate this process, we used the Intrinsic Motivation Inventory (IMI) to measure students' motivation after the lessons. Results show positive impact of gamification with stronger results in female students.*

Resumo. *A gamificação vem ganhando destaque nos últimos anos devido as inúmeras pesquisas realizadas em diversas áreas do conhecimento e os resultados positivos identificados pela comunidade. No ensino, este conceito vem sendo bastante difundido, no entanto, ainda há uma certa carência quanto a um processo sistemático para sua implantação. Este artigo apresenta um modelo conceitual de um processo de gamificação, para ser utilizado no ensino superior, tomando como base planos de aula e ementas. O resultado principal foi um processo gamificado, aplicado em uma turma de Bioquímica do ensino superior, no curso de Biotecnologia. Para verificar a eficácia do modelo foi utilizado o Intrinsic Motivation Inventory (IMI) que mede a motivação dos discentes após o uso da gamificação. Os resultados mostram que o método foi considerado divertido e interessante pelos alunos, principalmente quanto aos participantes do gênero feminino, além de ter uma boa aceitação por parte do docente responsável.*

1. Introdução

Os avanços tecnológicos permitiram ampliar a utilização das Tecnologias da Informação (TI) em diversas áreas. Dentre estas, a área de Educação e Ensino vêm se beneficiando por meio de sistemas e processos provindos da computação que possuem a capacidade de

* Os autores agradecem ao CNPq e a FAPESP (Processo 2016/02765-2) pelo apoio e financiamento deste projeto.

auxiliar e aprimorar as metodologias pedagógicas existentes [De Paula et al. 2014; Isotani et al. 2009].Dentre estas tecnologias, pode-se citar o uso de jogos digitais e seus processos derivados, como a gamificação. Este conceito vem adquirindo destaque, por conta de dos vários resultados positivos alcançados [Borges et al. 2013]. No entanto ainda há uma forte carência quanto a eficiência individual dos elementos de gamificação utilizados e processos sistemáticos para implantação adequada na gamificação em ambientes de aprendizagem [Dicheva et al. 2015; Thiebes et al. 2014; Andrade et al., 2016].

Um estudo realizado recentemente [Mora et al. 2015] demonstrou a extensão de *frameworks* para implantar o processo de gamificação em diversas aplicações. No entanto, segundo os autores, ainda há a necessidade de desenvolver um modelo genérico, que agregue qualidade no processo. Além disso, também comentam sobre a discrepância na avaliação e validação dos *frameworks* apresentados.

Baseando-se no exposto, este trabalho propõe um método para mapear elementos de jogos, em planos de aula e ementas, e aplicá-los no ensino superior, sendo validado através do *Intrinsic Motivation Inventory* (IMI). Para apresentar o estudo, o trabalho está dividido em: sessão 2 apresenta os conceitos e trabalhos relacionados a gamificação no ensino; sessão 3 apresenta o método desenvolvido, assim como o protocolo do experimento; sessão 4 apresenta os resultados encontrados, realizando uma breve discussão; sessão 5 apresenta as conclusões e trabalhos futuros.

2. Gamificação

O processo de gamificação pode ser conceituado como a utilização de elementos de jogos (como mecânicas, dinâmicas e estética) fora de seu escopo original, com o intuito de motivar, engajar e melhorar a experiência de usuário em diferentes situações com atividades de treinamento e ensino [Deterding et al. 2011; Huotari and Hamari 2012; Kapp 2012; Zichermann and Cunningham 2011].

A partir do uso de motivadores extrínsecos, o processo afeta a motivação intrínseca do usuário, suportada pela Teoria da Autodeterminação (SDT). Esta teoria, segundo Deci e Ryan (1985), defende que a motivação é sustentada por 3 pilares, sendo: Autonomia, Competência e Relacionamento. A autonomia se baseia no indivíduo ter controle sobre suas ações, já a competência consiste no indivíduo adquirir conhecimento e habilidade sobre algo. Por fim, o relacionamento consiste na necessidade do indivíduo de se conectar com outras pessoas [Deci and Ryan 1985].

Estes 3 pilares podem ser encontrados em jogos digitais, por exemplo: a Autonomia pode ser representada pelo controle do jogador sobre as ações de seu avatar virtual; a Competência pode ser encontrada no progresso do usuário dentro do universo do jogo; o Relacionamento pode ser representado nas relações virtuais que o jogador se engaja, para continuar o jogo [Aparicio et al. 2012].

3. Trabalhos Relacionados

Dentre os trabalhos relacionados, pode-se citar o estudo realizado por [Hanus and Fox 2014]. Neste trabalho, os autores analisaram a aplicação da gamificação em um contexto de ensino, analisando *performance* acadêmica, motivação, comparação social, satisfação e esforço. Os autores explanam que a combinação de elementos gamificados utilizados contribuiu para um desempenho acadêmico abaixo do esperado, e não influenciou de forma significativa na motivação, engajamento, satisfação e comparação social dos

discentes. No estudo realizado, eles associam a o rendimento à motivação intrínseca, que diminuiu durante a aplicação dos elementos de gamificação.

Outro trabalho interessante é o de [Mesquita et al. 2013, 2014], onde os autores desenvolveram uma metodologia gamificada para aulas de Linguagens e Técnicas de Programação, em um curso de Ciência da Computação. Neste, os autores obtiveram uma aceitação razoável dos elementos, mas não utilizaram métodos para medir a motivação ou *performance* dos indivíduos.

Além destes, pode-se citar também o trabalho de [Pedro et al. 2015], onde foi desenvolvido um ambiente de aprendizagem virtual e gamificado. Neste estudo, os autores explanam que os elementos de gamificação influenciaram de maneira positiva a *performance* dos participantes do gênero masculino, porém não foram encontrados resultados significativos em relação aos do gênero feminino.

4. Método

O método desenvolvido descreve 4 fases, sendo: Definição de conteúdo, Definição de Elementos de Jogos, Implantação e Validação. Na primeira fase, ocorre a análise dos planos de aula e ementas, elaborados pelo professor para aplicação da aula. Estes documentos foram escolhidos por fazerem parte do cotidiano do docente, e por conterem os conteúdos de forma organizada e sistemática [Takahashi and Fernandes 2004], auxiliando na geração de um mapa conceitual para a disciplina (Figura 1).

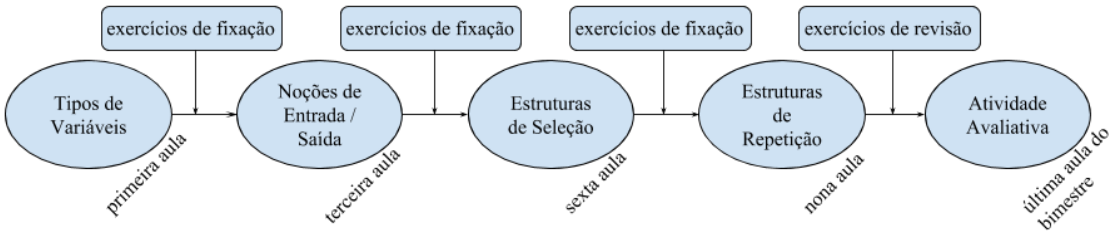


Figura 1: Exemplo de Mapa mental de uma disciplina de Noções de Programação
Fonte: Autores (2016)

A Figura 1 apresenta um exemplo de mapa conceitual, gerado a partir de uma ementa, de um curso de Noções de Programação. Para geração do mapa, é importante considerar o conteúdo que será ministrado e as atividades vinculadas a este (definir ações). O mapa também é importante para auxiliar na definição dos elementos de jogos, que será realizada na Fase 2. Esta fase também é importante para definir o período em que cada conceito será ministrado pelo docente, auxiliando na organização da disciplina.

Em seguida, a Fase 2 define os elementos (mecânicas e dinâmicas) que serão utilizados. Para auxiliar o docente responsável na seleção, foi elaborado um conjunto de conceitos divididos em: Elementos de *Feedback*, consistem em motivadores extrínsecos aplicados a ação, e Elementos de Propriedade, que consistem nas características e objetivos da ação desenvolvida.

Estes elementos foram definidos a partir de pesquisas realizadas em revisões sistemáticas [Borges et al. 2013; Dicheva et al. 2015; Hamari et al. 2014] e do conjunto de elementos para jogos comportamentais desenvolvido por Dignan (2011). A listagem com a descrição dos elementos pode ser observada na Tabela 1:

Tabela 1: Divisão dos elementos

Elementos de Feedback			Elementos de Propriedade		
Reputação	Pontos	Conquistas	Cooperação	Renovação	Narrativa
Troféus	Níveis	Progresso	Competição	Pressão	Economia
			Decisões	Atividades Cognitivas	Oportunidades
			Aleatoriedade	Segredos	Novidade

A partir da combinação dos elementos presentes na Tabela 1, o docente responsável pode gerar diversas dinâmicas para serem aplicadas durante, ou todo, o período da disciplina. Para auxiliar na organização deste processo, foi gerada a Tabela 2.

Tabela 2: Tabela de Ações

Nome da ação:	Data:
Descrição:	
Propriedades:	
Feedback:	
Comentários / Acompanhamento:	

Após a definição dos conceitos que serão abordados, ações e elementos de jogos, inicia-se a fase de Implementação. Esta consiste da aplicação das ações definidas na Fase 2. Para isso, é necessário um momento com os participantes da disciplina para explanação das regras operacionais que terão vigência durante todo o curso, as regras de atividades específicas podem ser explanadas neste momento, porém recomenda-se que sejam focadas apenas quando forem realizar a ação (de modo a não confundir o discente, num momento inicial).

Durante a fase de implantação, é recomendado ao docente que realize encontros para medição da satisfação da turma como um todo, a fim de evitar que discentes sejam penalizados por conta do processo. Por fim, é realizada a Fase 4, validação, por meio de questionários. A Tabela 3 apresenta a descrição das principais funções de cada fase.

Para validar o processo, é utilizado o *Intrinsic Motivation Inventory* (IMI), um instrumento de medição multidimensional que visa avaliar a experiência subjetiva do usuário, quanto a atividade realizada. Após coleta a análise das respostas, é possível planejar a próxima iteração, utilizando também os relatos dos alunos.

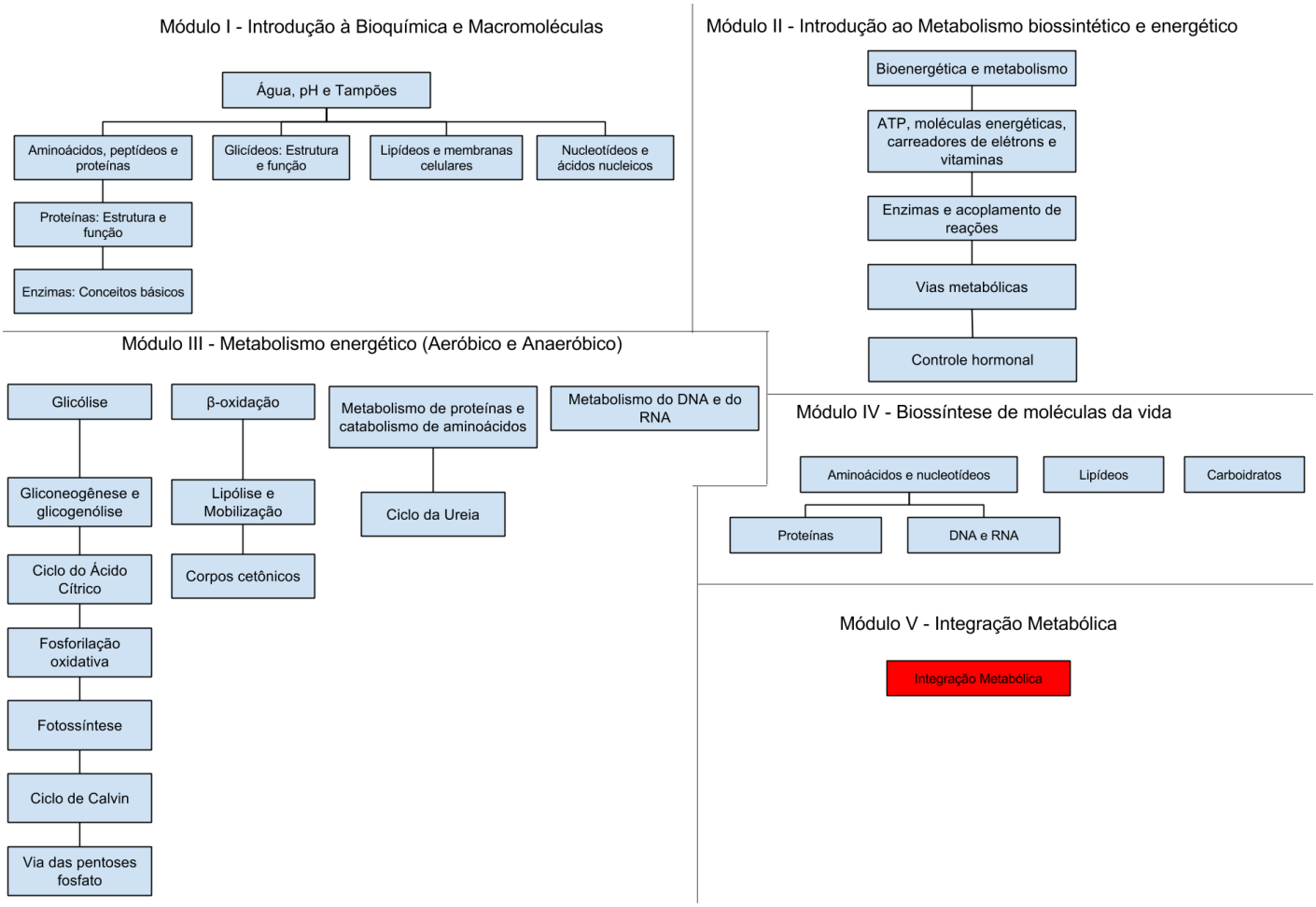
Tabela 3: Resumo de execução do método

Fase	Descrição
Definição dos Conteúdos	Analisar planos de aula e ementas Gerar mapa conceitual Definir tempo da disciplina Definir Ações

Definição dos Elementos de Jogos	Definir Elementos de feedback das ações Definir elementos de propriedade das ações Definir dinâmicas Preencher Tabela de Ações
Implantação	Explanar as ações que serão desenvolvidas Explanar as regras envolvidas Aplicar o método
Validação	Aplicar o IMI para avaliar a motivação do discente Coletar relatos Analisar respostas para próxima iteração

5. Resultados e Discussões

Esta seção apresenta os resultados a partir da aplicação do método em uma disciplina modular de Bioquímica, no curso de Biotecnologia. Primeiramente foi realizada a



Definição dos Conteúdos, estabelecendo o tempo da disciplina (5 meses, divididos em 32 aulas) e gerando os mapas conceituais. Estes mapas foram divididos em módulos, agregando os temas que foram abordados, conforme pode ser visualizado na Figura 2.

Figura 2: Mapa da definição dos temas por modulo (Fonte: Autores, 2016)

Após a Definição dos Conteúdos, iniciou-se a Fase 2, Definição dos Elementos de Jogos, onde o docente selecionou as mecânicas que mais se adaptavam ao seu plano de ensino, gerando uma série de dinâmicas. Baseando-se na Tabela 1, o docente da disciplina determinou que seu plano de ensino utilizaria as seguintes mecânica: Pressão (temporal), Oportunidades, Atividades Cognitivas, Competição, Níveis, Progresso, Cooperação, Aleatoriedade, Pontos e Economia.

Haviam dinâmicas que foram aplicadas em toda a extensão da disciplina (como elementos de Economia e Progresso) e algumas que eram específicas para algumas atividades, um exemplo pode ser observado na Tabela 4.

Tabela 4: Exemplo da dinâmica Lista de Exercícios Individuais

Nome da ação: Lista de exercícios individual	**Duração:** Final de cada módulo
Descrição: Será aplicada uma lista de exercícios, sendo resolvida individualmente. Ao final, será atribuído um número de pontos baseado na correção da lista.	
Propriedades: Pressão temporal: Data de entrega sem prorrogação Oportunidades: Todos os alunos com acesso as mesmas questões Atividades cognitivas: Exercícios da lista Competição: Mapa do progresso coletivo, mostrando todos os alunos	
Feedback: Níveis: As listas são interdependentes, a entrega de uma é necessária para receber a próxima Progresso: Mapa de progresso individual Pontos: A pontuação da lista será atribuída a nota do aluno	
Comentários / Acompanhamento: Regra para distribuição de pontos: Cada acerto na lista rende ao aluno 1 ponto, que pode ser utilizado no mercado individual, ou coletivo (Ação que engloba toda a disciplina).	

Em seguida, iniciou-se a fase de Implantação. No início desta fase, foi explanado aos alunos as regras geradas e as ações que seriam desenvolvidas juntamente com o cronograma da disciplina. Também foi questionado se todos estavam de acordo, aqueles que não concordaram com a abordagem da disciplina seguiriam um método tradicional, sem aplicação das ações gamificadas. No entanto, todos os alunos que atenderam a disciplina (N=24) concordaram em participar do processo gamificado.

Por fim, foi aplicado o *Intrinsic Motivation Inventory* (IMI) para medir a motivação dos discentes, a fim de avaliar se o processo obteve o efeito engajador que objetivava. Este questionário visa identificar certos aspectos relacionados a motivação do indivíduo, através de uma escala Lickert de 7 itens onde 1 significa "Não é verdade" e 7 significa "Totalmente verdade". Estes aspectos são divididos em grupos, a saber: Interesse/Aproveitamento, Competência Percebida, Importância/Esforço, Pressão/Tensão, Escolha Percebida, Valor/Utilidade e Relacionamento. O questionário utilizado neste estudo foi construído com 21 questões, sendo aplicado e preenchido de forma manual (papel e caneta), ao fim da disciplina, abrangendo perguntas dos grupos: (A) Interesse/Aproveitamento, (B) Competência Percebida, (C) Pressão/Tensão e (D) Escolha Percebida. Para analisar os resultados coletados, foi considerada a média (μ) das respostas (Tabela 5).

Tabela 5: Perguntas do IMI e a média (μ) por gênero

ID	Grupo	Pergunta	$\mu(F)$	$\mu(M)$
P1	A	Enquanto eu estava fazendo a atividade, eu estava pensando o quanto estava aproveitando	4,1	3,8
P2	C	Eu não me senti nervoso(a) enquanto fazia a atividade.	4,9	4,8
P3	C	Eu senti que foi minha escolha fazer essa atividade.	4,7	4,4
P4	B	Eu acho que sou muito bom nessa atividade.	3,5	3,8
P5	A	Eu achei essa atividade muito interessante.	6	5,2
P6	C	Eu me senti tenso durante essa atividade.	2,9	3,3
P7	B	Eu acho que me sai bem nessa atividade, comparado com outros estudantes.	4,3	3,7
P8	A	Fazer essa atividade foi divertida.	6	5,4
P9	C	Eu me senti tranquilo(a) fazendo essa atividade.	3,8	4,2
P10	A	Eu gostei muito de fazer essa atividade.	5,2	4,2
P11	D	Eu não tive muita escolha em fazer essa atividade.	3,2	4
P12	B	Eu estou satisfeito(a) com o meu desempenho nessa atividade.	4,4	4,5
P13	C	Eu estava ansioso(a) durante a atividade.	3,8	3,3
P14	A	Eu achei essa atividade muito chata	1,9	2,2
P15	D	Eu senti que eu estava fazendo o que eu queria, enquanto eu estava fazendo a atividade.	4,6	3,6
P16	B	Me senti muito competente nesta atividade.	4,4	3,7
P17	A	Eu achei a atividade muito interessante.	6	5
P18	C	Eu me senti pressionado enquanto fazia a atividade.	3,7	3,2
P19	D	Eu senti obrigação de fazer essa atividade.	3	4,5
P20	A	Eu descreveria essa atividade como muito agradável.	4,6	5,3
P21	D	Eu fiz essa atividade porque eu não tive escolha.	3	3,2
P22	B	Depois de fazer essa atividade por um tempo, me senti muito competente.	4,9	4,1

Dentre os resultados encontrados na Tabela 5, pode-se destacar algumas análises como: Os participantes do gênero feminino refletiram mais sobre seu aproveitamento

durante o curso ($P1$: $\mu(F) = 4.1 > \mu(M) = 3.8$ (dif 0.3)), além de acharem que se saíram melhor que os demais ($P7$: $\mu(F) = 4.3 > \mu(M) = 3.7$ (dif0.6)) .

Já os participantes do gênero masculino se sentiram menos tranquilos durante a aplicação do método ($P9$: $\mu(M) = 4.2 > \mu(F) = 3.8$ (dif 0.4)), além de sentirem que não tiveram escolha em participar do processo ($P11$: $\mu(M) = 4.0 > \mu(F) = 3.2$ (dif 0.8)) ou que não estava fazendo o que queria enquanto participava($P15$: $\mu(M) = 3.6 < \mu(F) = 4.6$ (dif 1.0)), além de se sentirem obrigados a terem participado ($P19$: $\mu(M) = 4.5 > \mu(F) = 3.0$ (dif 1.5)). Os participantes deste gênero também não se sentiram competentes enquanto realizavam a atividade ($P16$: $\mu(M) = 3.7 < \mu(F) = 4.4$ (dif 0.7)), no entanto se sentiram competentes após o término da mesma ($P22$: $\mu(M) = 4.1$). No geral, os alunos acharam que o curso foi muito interessante ($P5$: $\mu(Geral) = 5.6$) e divertido ($P8$: $\mu(Geral) = 5.7$).

Por fim, foi realizado uma entrevista com o docente responsável pela disciplina, visando coletar informações para melhorar o processo. De acordo com as respostas coletadas, o docente informou que utilizou uma planilha eletrônica para controlar os elementos que foram implantados, e que a presença de uma ferramenta computacional mais eficiente (ou direcionada) poderia auxiliar neste processo. Também foi exposta a satisfação do docente e que ele planeja utilizá-lo novamente em aulas futuras.

Sobre as discussões do trabalho, em relação ao trabalho realizado por [Hanus and Fox 2014], pode-se observar que o conjunto de elementos utilizados neste estudo influenciou positivamente na motivação e satisfação dos alunos. No entanto, não foi avaliado se a *performance* deste grupo foi influenciada, ou a comparação social.

Em relação ao estudo realizado por [Mesquita et al. 2013, 2014], o método desenvolvido proporcionou a avaliação da motivação e satisfação dos alunos, encontrando resultados satisfatórios ($\mu(Grupo\ A) = 4.6$), utilizando mecânicas similares, porém com um processo mais detalhado e que aborda o uso de materiais desenvolvidos pelos docentes.

Outra observação pertinente é quanto a aceitação pelo gênero, uma vez que, conforme visualizado no trabalho de [Pedro et al. 2015], os participantes do gênero masculino tiveram uma *performance* maior que os do feminino. No escopo deste estudo, as mulheres tiveram uma aceitação maior que os rapazes. Isto pode ter sido influenciado pela seleção do conjunto de elementos de gamificação.

Outro fator que pode ter influenciado na diferença é a idade, uma vez que os perfis dos participantes deste trabalho são de alunos do ensino superior, enquanto que no outro trabalho são crianças. Por fim, relacionado os dois estudos, os participantes do primeiro estudo interagiram diretamente com um sistema, desenvolvido pelos autores, sem a intervenção de um professor, enquanto este foi aplicado diretamente em sala de aula, havendo a intervenção do docente responsável pela disciplina.

Conforme pode ser observado nos demais trabalhos, não foi o foco deste avaliar a performance dos alunos, podendo ser explorado em trabalhos futuros. O *feedback* do docente também foi importante para auxiliar na evolução do método, através da construção de uma ferramenta computacional adaptativa para os tipos de elementos que forem selecionados.

6. Conclusões e Trabalhos Futuros

Este trabalho apresentou uma proposta de método para gamificar aulas e/ou cursos no ensino superior, utilizando planos de aula e ementas como base. O processo foi utilizado em uma disciplina de Bioquímica do curso de Biotecnologia. Os resultados encontrados demonstram que o método foi considerado divertido e interessante, e que grande parte dos alunos se sentiram satisfeitos enquanto participavam do curso.

Uma das principais contribuições do trabalho é a aplicação do método em um curso de Ciências Biológicas, visto que a maioria das aplicações realizadas são nas áreas de Computação e Engenharia, com um perfil de discentes mais propício aos elementos de jogos presentes na gamificação.

Além disso, acredita-se que este trabalho também contribua diretamente para a área de ensino de modo a fornecer uma estratégia para o uso do processo de gamificação em conjunto com planos de aula, ementas e outros documentos organizacionais, produzidos pelo professor. Deste modo, facilitando a implantação do processo nas aulas ministradas.

Por fim, os elementos customizáveis apresentados no modelo permitem que este se adapte a diversos públicos, visto que este é uma das grandes dificuldades de trabalhar com o processo em um ambiente heterogêneo, onde não se conhece o perfil de cada aluno. Deste modo, é possível estudar os efeitos que os elementos implementados implicam nos discentes.

Como trabalhos futuros, espera-se melhorar a formalização do método, assim como aplicar uma metodologia mais específica para o desenvolvimento de atividades colaborativas, visando os objetivos educacionais e suportada pela Teoria da Autodeterminação. Além disso, também espera-se implantar o processo em outras áreas do conhecimento, a fim de explorar os perfis de alunos e elementos que são mais propícios a engajá-los. Por fim, espera-se poder realizar um estudo longitudinal a fim de verificar se o método influência de forma positiva na performance dos alunos.

Referências

Andrade, F. R., Mizoguchi, R., and Isotani, S. (2016, June). The Bright and Dark Sides of Gamification. In International Conference on Intelligent Tutoring Systems, LNCS 9684, pp. 176-186.

Aparicio, A., Vela, F., Sánchez, J. and Montes, J. (2012). Analysis and application of gamification. In *Proceedings of the 13th International Conference on Interacción Persona-Ordenador*.

Borges, S. de S., Durelli, V. H. S., Reis, H. M. and Isotani, S. (22 nov 2013). Gamificação Aplicada à Educação : Um Mapeamento Sistemático. *Anais do Simpósio Brasileiro de Informática Educativa*, n. July 2015, p. 234–243.

Deci, E. L. and Ryan, R. M. (1985). *Intrinsic Motivation and Self-Determination in Human Behavior*. Boston, MA: Springer US.

Deterding, S., Sicart, M., Nacke, L., O'Hara, K. and Dixon, D. (2011). Gamification. using game-design elements in non-gaming contexts. *Proceedings of the 2011 annual conference extended abstracts on Human factors in computing systems - CHI EA '11*, p. 2425.

De Paula, B. H. ; Valente, J.A. ; Burn, A. . Game-Making as a means to deliver the new computing curriculum in England. Currículo sem Fronteiras , v. 14, p. 46-69, 2014.

Dicheva, D., Dichev, C., Agre, G. and Angelova, G. (2015). Gamification in Education : A Systematic Mapping Study. *Educational Technology & Society*, v. 18, n. 3, p. 1–14.

Dignan, A. (2011). *Game Frame*. Free Press.

Hamari, J., Koivisto, J. and Sarsa, H. (2014). Does Gamification Work? - A Literature Review of Empirical Studies on Gamification. *2014 47th Hawaii International Conference on System Sciences*,

Hanus, M. D. and Fox, J. (sep 2014). Assessing the effects of gamification in the classroom: A longitudinal study on intrinsic motivation, social comparison, satisfaction, effort, and academic performance. *Computers & Education*, v. 80, p. 152–161.

Huotari, K. and Hamari, J. (2012). Defining gamification: a service marketing perspective. *Proceeding of the 16th International Academic MindTrek Conference*, p. 17–22.

Isotani, S., Bittencourt, I. I., Mizoguchi, R., Costa, E (2009). Estado da Arte em Web Semântica e Web 2.0: Potencialidades e Tendências da Nova Geração de Ambientes de Ensino na Internet. Revista Brasileira de Informática na Educação, v. 17, p. 30-42.

Kapp, K. M. (1 may 2012). The Gamification of Learning and Instruction: Game-based Methods and Strategies for Training and Education.

Mesquita, M. A. A., Toda, A. M., Brancher, J. D. and Do Carmo, R. M. C. (5 mar 2014). Utilizing gamification with social network to aid students in programming languages lessons in higher education IT courses (abstract only). In *Proceedings of the 45th ACM technical symposium on Computer science education - SIGCSE '14*. . ACM Press.

Mesquita, M., Toda, A., Brancher, J. and Do Carmo, R. (2013). Utilizing Gamification concepts tied with Social Networks to support students in programming classes. *Proceedings of the XV Simpósio Internacional de Informática Educativa*, p. 127–132.

Mora, A., Riera, D., Gonzalez, C. and Arnedo-Moreno, J. (sep 2015). A Literature Review of Gamification Design Frameworks. In *2015 7th International Conference on Games and Virtual Worlds for Serious Applications (VS-Games)*. . IEEE.

Pedro, L. Z., Lopes, A. M. Z., Prates, B. G., Vassileva, J., Isotani, S (2015). Does gamification work for boys and girls?. In: Proceedings of the 30th Annual ACM Symposium on Applied Computing - SAC '15. New York: ACM Press. p. 214-219.

Takahashi, R. T. and Fernandes, M. de F. P. (2004). Plano De Aula: Conceito E Metodologia. *Acta Paui Enf.*, v. 17, n. 1, p. 114.

Thiebes, S., Lins, S. and Basten, D. (2014). Gamifying information systems A synthesis of gamification mechanics and dynamics. *Twenty Second European Conference on Information Systems*, p. 1–17.

Zichermann, G. and Cunningham, C. (2011). *Gamification by Design: Implementing Game Mechanics in Web and Mobile Apps*. O'Reilly Media; 1 edition.

ANNEX

H

AN APPROACH FOR PLANNING GAMIFICATION CONCEPTS WITH SOCIAL NETWORK FEATURES WITHIN EDUCATIONAL CONTEXTS

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Research Note

An approach for planning and deploying gamification concepts with social networks within educational contexts

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ABSTRACT

Gamification planning has been a topic of discussion in the last years since it can be used to increase performance, engagement, and motivation of end users. When properly applied in educational settings, gamification can lead to better learning. Furthermore, it can be boosted when tied to social networks. However, according to the literature, there are three main concerns regarding this topic: (a) instructors and teachers does not have the resources to plan and develop gamification strategies into their classes; (b) gamification needs a systematic approach to achieve the desired positive results; and (c) inexistence of systematic approaches that connect and help in the design of gamification and social network tasks within these contexts. Thus, this work proposes a solution to help instructors and teachers to plan and deploy gamification concepts with social network features in learning environments. In this paper, we detailed our approach depicting the set of items to analyze and compare it with other solutions that are focused on education. Then, it was conducted a case study over a programming course ($N = 40$) to analyze the planning and deployment phases. Our results demonstrated that our approach is the first to consider the stakeholders (i.e. instructors and teachers) as part of the process. Moreover, even though there are still some obstacles to overcome, the gamified strategies that were created achieved positive acceptance among the students and professor.

1. Introduction

Gamification approaches are methods, processes and frameworks (Mora, Riera, González, & Arnedo-Moreno, 2017) that help users to define systematically how to use game elements in a specific non-game context, as Werbach & Hunter Six Steps to Gamification (Werbach & Hunter, 2012) and Marczewski G.A.M.E framework (Marczewski, 2015). The number of these approaches have increased in the past few years, due to the popularity of the term and positive results that were achieved and the growing interest in games due to its usefulness and enjoyment, especially in the education field (Dichev & Dicheva, 2017; Hamari & Keronen, 2017; Hamari & Koivisto, 2015). According to Zichermann and Cunningham (2011) these systematic approaches are necessary to provide good results. Although a significant number of frameworks and processes have been created in the past years, there is still a lack of approaches that focus on educational areas and that consider the stakeholder as part of the process (Mora et al., 2017). These stakeholders, usually instructors and teachers, have interest on using gamification in their educational contexts. However, constraints in time and resources to help them to plan and deploy gamification are scarce (Martí-Parreño, Seguí-Mas, & Seguí-Mas, 2016; Sánchez-Mena & Martí-Parreño, 2016). Finally, there is a lack of approaches that connect gamification with social networks due to the complexity of merging them. In this work, we adopt the definition of Boyd and Ellison (2007) of Social Network Sites, according to the authors, these are web-based services that allows individuals to construct a public or private profile and manage a list of connections and interaction with other users. We believe that using SNS, as web technologies, is reasonable because according to the literature, the benefits of gamification (such as the increase in motivation, performance, and engagement of students) can be boosted when applied together with social network features (Borges, Durelli, Reis, & Isotani, 2014; De-Marcos, Garcia-Lopez, & Garcia-Cabot, 2015; Kapp, 2012; Lim, Lee, & Nam, 2007; Paiva, Bittencourt, Tenório, Jaques, & Isotani, 2016; Parikh & Verma, 2002; Tenório, Bittencourt, Isotani, Pedro, & Ospina, 2016; Zichermann & Cunningham, 2011). Finally, the literature also states that by integrating e-learning technologies and face-to-face learning ensures that the learner is stimulated through the process (Chang, 2016). Although

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our chosen social network does not have educational purposes, we aimed at identifying functionalities that could be used to improve the learning process.

Based on this premise, the main objective of this work is to develop an approach, by incrementing an existing meta process (Toda, do Carmo, da Silva, & Isotani, 2018), to help the instructor to plan and deploy gamification with social networks in their courses. To develop this approach, this work will: (a) introduce guidelines for planning and deployment of gamification; (b) develop an instrument to validate the social network and gamification concepts, along with the instructor's influence; (c) conduct a study in a real environment; and (d) analyze this process using the criteria defined by Mora et al. (2017).

Thus, it was conducted a case study within a programming course in an undergraduate computer science course. The class was composed of 40 students and a group of instructors. It was also developed a tool to evaluate the acceptance of gamification concepts within the social network frequency and the influence of the instructors in the approach. It was also provided a qualitative analysis of our approach called GAMIFY-SN based on the items proposed by Mora et al. (2017).

To present our work, we divided the paper as it follows: Section 2 presents the related works; Section 3 presents the approach, along with its methods and tools that were used to perform the case study; Section 4 presents the results and discussions; Section 5 presents the conclusions and future works.

2. Related works

This section present works that relates gamification in educational contexts. Although there are a significant number of studies in this field (Dichev & Dicheva, 2017) as the framework of Klock et al. (2015) which apply gamification in virtual learning environments, or the work of Toda, Silva, Cruz, Xavier, and Isotani (2016) that applied a meta-process in biochemistry classes, we focused on presenting works that intersects gamification and social network concepts. The earliest research was conducted by Thom, Millen, and DiMicco (2012) where the authors deployed a social network with gamification concepts in a business context. The main objective of this study was to analyze the removal of gamification concepts from the enterprise social network. The gamification of this system aimed to increase user participation by giving points to those who sent messages, uploaded photos, or used other features from the social network. The employee's interactions within the system were represented by a leaderboard. In this study, the authors reported that 3486 interactions between the subjects were analyzed with gamification elements and without the gamification elements. According to the authors, the removal of the points decreased drastically the participation and interactions within the enterprise social network. Although this work presents empirical and significant evidence on the impact of gamification removal, it does not present a systematic way to implement gamification within social networks, nor to apply it in an educational context.

Next, De-Marcos et al. (2015) performed an experiment, providing positive empirical evidence on the utilization of gamification with social networks. The authors defined four groups, besides the control group, aiming to analyze an educational game, a gamified system, a social network, and a social network with gamification concepts. According to the authors, students that were in the social network with gamification concepts groups achieved the highest scores and consequently obtained a better performance than the other groups. The study is relevant for presenting empirical evidence on the subject. However, the authors did not focus on the instructor's point of view, nor in a systematic approach to help in the implantation of the game elements within those environments.

Another relevant work is the one conducted by Wongso, Rosmansyah, and Bandung (2014) where they proposed a gamification framework model based on social engagement and Web 2.0 features. The conceptual framework is divided in five steps: Analysis, where the researchers must define the Web 2.0 and social features and gamification features (six elements, reward system, point system, achievements, challenges, feedback and leaderboards); Design, where the features defined in the previous step will be used to build a blueprint. During this phase, the researchers also prepare the learning materials, by dividing previous learning assignments in smaller ones that will allow the students' to visualize their progress; Development, where the researcher must connect the web 2.0 features and gamification elements that were chosen; Implementation, where someone is responsible to code the features within an e-learning system or build it from scratch; and Evaluation, where the learner is assessed within the system that was modified or developed. Although the framework presents some ideas regarding the use of social elements, it is focused on using existing e-learning systems as Moodle or Blackboard. Also, the authors did not evaluate or instance the framework to verify its applicability.

Finally, Araújo and Pestana (2017) proposed a framework for social and physical well-being in the workplace using gamification techniques. The authors propose an approach that focus on improving well-being as well as to improve their skills in specific subjects (“soft” and “hard” skills). These skills were represented through a gamified dashboard where the gamification allowed a self-assessment of the expected behaviors. Although the framework focused on using gamification to improve motivation and skill acquisition and the dashboard present some SNS concepts, it is not applied within an educational context.

Although these studies are related, one of them do not present gamification and social network in educational context, another present an empirical study but not how to gamify using those concepts, and finally the last one provides a work in progress guidelines, however do not present empirical evidence. Based on these studies, we proposed the definition of a systematic process that can aid in the planning and deployment of gamification within social networks, and an analysis with the students and instructors that were enrolled in the course. And instanced that approach through a case study.

3. GAMIFY-SN

This section has the objective to explain the GAMIFY-SN approach, to help the instructors to plan and deploy gamification concepts within social networks. It also explains the method of analysis that was performed to collect the properties of the approach.

3.1. Guidelines

The approach requires a game designer and an instructor to work properly, with each role performing their specified tasks. The instructor (or teacher with knowledge in instructional design) is responsible for developing and applying the instructional objectives of the class. The game designer, on the other hand, is responsible to help the instructor to choose the right game elements to pursue the instructional behaviors that are intended, and to help in the evaluation process of those behaviors.

The approach is divided in four steps, each one with their own sub-steps that must be followed to assure the efficiency of the approach. These steps are: Defining the content, Defining the Game Elements, Deployment, and Evaluation (Fig. 1). Each step requires one of the two, or both, roles associated with the approach (Instructor and Game Designer).

The first step is the Definition of the Content, which is performed by the instructor. This phase contains four sub-steps, which are the analysis of content, the mapping of activities, mapping of social network features and the representation. The first sub-step consists in analyzing the previous content that was generated by the instructor to understand and define the tasks that were proposed to achieve a certain instructional objective. This content can be represented through any instructional resource used in traditional instructional lessons, e.g. lesson plans or lesson summaries. Following that, the instructor must map the

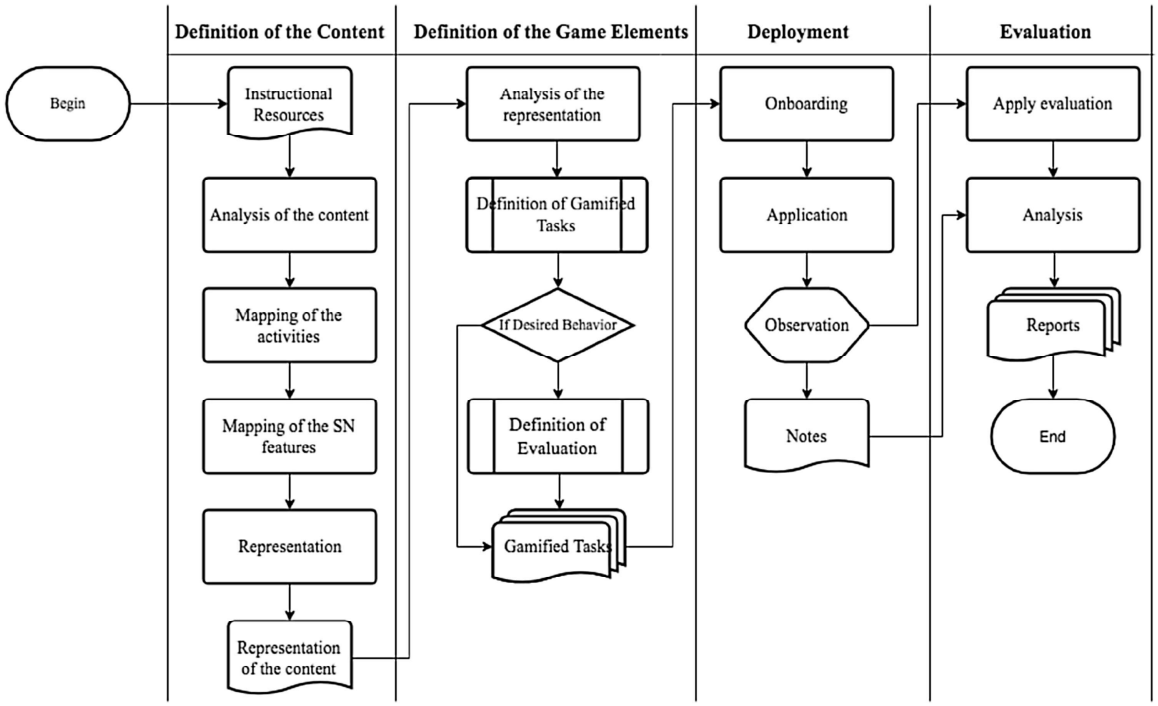

Fig. 1. Flow chart describing the GAMIFY-SN. **Normal rectangles** represent actions of each sub-step. **Wave rectangles** represent the documents that are generated or used. **Rectangle with sides** represent an action with other sub-steps within. **Diamond** represent conditions. **Hexagon** represent the observation sub-step which is performed during the deployment phase in a physical/virtual environment.

tasks that will be performed; these tasks can be represented as activities or another kind of evaluation that is used within the instructional content. Next, the instructor must select the social network features intended to be used within the tasks, to help in the understanding of the instructional content. Due to the increase of social network sites in the last decade, we provide some features that are shared by most of them (e.g. Twitter, Facebook, GooglePlus) as: Posting a comment on a users' activity, where the users can comment or reply to a status update regarding the course; Update and/or Sharing status, regarding course or content information; Post materials (photos, videos or other supported types of files) about the content or other relevant information to the course; Add course colleagues and create groups to encourage cooperation (Boyd & Ellison, 2007; Wongso et al., 2014).

These instructional tasks, tied or not to a social network feature, contain a desired behavioral outcome, and these outcomes will help the game designer to choose the right evaluation for the instructor and the mapping of the tasks will support the instructor to create the representation of the lesson plans. This representation is used to understand the logical flow of the content and how the tasks are connected to it. This structure can also help the game designer to propose a set of elements to use within the lesson or each of the tasks. Followed by the creation of the representation, it is the first step of the Definition of the game elements phase.

The second phase of the process requires the structure that was generated in step one, and both the instructor and the game designer. It is divided into three sub-steps which are: Analysis of the Representation, Definition of the Gamified Tasks and Definition of Evaluation. To help the game designer to choose the game elements, we defined the concept of Gamified Task. This Gamified Task allows the use of game elements in the instructional task following the structure of an instructional task. This instructional task contains an instructional objective (which is the main goal of what is intended to be accomplished by the teacher) tied to an event that will be performed by the instructor, e.g. make the students learn a concept, through expositive classes. However, the instructional objective is tied with a game property and feedback, as the strategy that will use those elements (Fig. 2).

The objective of the gamified task is the same objective of the instructional task, e.g. make the student understand a concept definition. The instructional resources were previously defined by the instructor, which can also be some of the social network features, e.g. the social network of choice, writing tasks, digital presentations, etc. Following the instructional resources, the game designer can help to select the best game elements, divided into feedback and property. These elements were based on Dignan's framework for developing behavioral games (Dignan, 2011; Toda et al., 2016). The feedback elements can be used to help in achieving the objective of the gamified task, allowing the instructor some freedom on which elements to use on which tasks. To illustrate the use of these elements, it is presented a brief conceptualization of each one in Table 2, along with some examples on how to use them in educational contexts and the works that also used those elements.

Based on the elements presented on Table 2, the instructor, along with the game designer, can create gamified strategies within their gamified tasks, without modifying its instructional structure e.g., The objective of the task is to make the students learn a specific content about math using the features of posting comments on the SN forum. To achieve this objective, the game designer can propose the use of cooperation property and a point feedback, along with trophies to generate the following strategy: "When the students reply a post with relevant information, both students get points, and when they reach a certain amount of points they get a badge of "Big Helper" (Hypothetical name), representing the success of those students"_. Based on the desired behavior, which could be defined in the representation, the designer may also propose a form of evaluation, e.g. if the task is related to increasing student's motivation, the designer may propose the use of the Instructional Materials Motivation Survey (IMMS), which is based on Motivational Design, to measure students' motivation. After defining the gamified tasks that will be used within the class, the instructor can begin the Deployment phase.

In the Deployment, the instructor applies the gamified tasks within their lessons. This phase is represented by three sub steps: Onboarding, Application, and Observation. The Onboarding is a pre-lesson where the

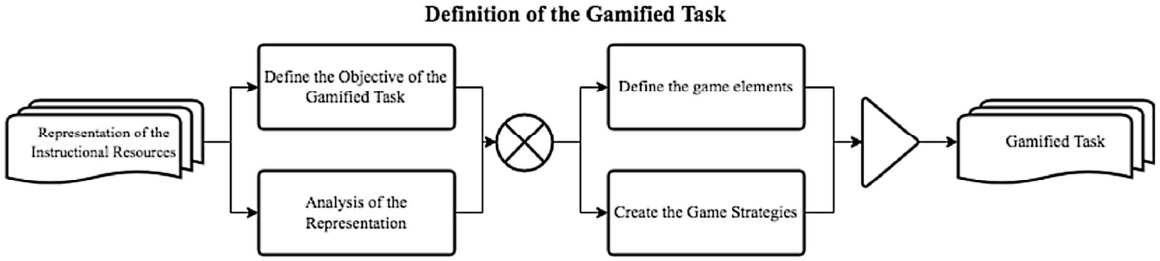

Fig. 2. Gamified Task.

instructor explains the instructions of the gamified tasks, the length and other rules associated with it. Also, the gamified tasks should not be mandatory, since the students have the choice whether they want to "play"_ the lesson or not. The application consists in the deployment of the gamified tasks as they were planned. As for the Observation sub-step, the instructor, alongside any support, may observe the behavior and acceptance of the game elements by the students. This observation can be performed through questionnaires or notes taken in classes during and after a gamified task. These notes are important for the analysis to understand how the students react to the game elements that are being applied.

Finally, after the Deployment phase, we begin the evaluation phase. This consists in the application of questionnaires to evaluate the intended behavior and the acceptance of the gamified tasks. The acceptance of the gamified tasks is important for the game designer to improve those tasks in future instances. After the evaluation, an analysis is performed by the game designer and reports are created to depict the results. In the scope of this project, the instructor aimed to evaluate the students' performance. However, it was evaluated the meta-process in 3 dimensions: the social network use and frequency, the gamification elements acceptance and the instructor's influence, from the viewpoint of the students. It was also interviewed the instructor and his assistants after the study to collect feedback about the meta-process.

3.2. Qualitative evaluation

To analyze our approach, we conducted individual in-depth interviews (DiCicco-Bloom & Crabtree, 2006; Opdenakker, 2006) with four experts, two from the computers applied to education domain and two from the gamification domain. Each interviewee received a partial documentation of the approach (as seen on https://docs.google.com/document/d/1U0YVism_m4shOA_ctSmc-JvW4qj7p5ZsxuDQE0YU224/edit?usp=sharing) to be prepared for the interview. We based our questions on the assessment proposed by Mora et al. (2017). This evaluation consisted in analyzing 21 game-related items divided into six categories, one qualitative (Principles) and five quantitative (Knowledge, Logic, Psychology, Measurement, and Interaction). They were based on relevant design principles that were commonly found in these approaches. A summary of these items can be seen in Table 1.

We used the same scale proposed by Mora et al. (2017), by verifying with the experts if our approach contained each Item explicitly (E), implicitly (I) or unreferenced (U).

4. Results

This section presents the contributions of this research. Initially, it is presented the qualitative assessment of our approach to demonstrate its advantage, and then it is explained the planning and deployment of the case study, along with the results that were found.

4.1. Qualitative evaluation

Based on what was exposed in Section 3.2 our interviews were conducted through instant messengers and audio calls to facilitate the communication with the interviewees. This analysis was divided into five groups, the same proposed by Mora et al. (2017). A summary of the interviewee's answers can be seen in Fig. 3.

Table 1
Items proposed by Mora et al. (2017).

	Item	Description
Knowledge	Objective	Specific performance goals
	Feasibility	Evaluation and analysis of the potential of applying gamification
	Risks and weakness	Probability of any negative occurrence
	Investment	Benefit resulting from the gamification
	Stakeholders	Identify and consider the people who interact with the process
Logic	Engagement cycle	Game mechanics combined with reinforcement and feedback (Dynamics)
	End-game	Pre-established end game
	On-boarding	Introduction to the new participants
	Rules	Body of regulations depicted by the designer
Psychology	Fun	Enjoyment or playfulness
	Motivation	Behavior that make people want to redo an action
	Social interaction	Interaction between participants
	Desired behavior	Expected response of participants after interaction
	Profiling	Identify the participants
	Players' taxonomy	Player type categorization
Measurement	Analytics	Algorithms and/or data used to measure key performance indicators
	Metrics	Standards of measurement
	Ethics	Recommendation of right and wrong conducts
Interaction	Storytelling	Context created by the designer
	User experience	Everything within the gamified practice that can be interacted by the participant
	Technology	Use or need of a software or component

4.1.1. Knowledge

Regarding the Knowledge Item, most of the interviewees (75%) agreed that the documentation contained an explicit objective of our approach, while one expert said it was not very clear, but it could be abstracted. As for the feasibility, there were mixed results. The experts from computers in educational domain agreed that feasibility was explicit for them, since the roles and its activities were clearly explained. However, the gamification experts believed that this feasibility was lacking in the document, considering unreferenced. Risks and Weakness did not achieve a consensus, with two interviewees agreeing that they were implicit, one saying it was explicitly based on their experience and other saying it was unclear in the documentation. Investment also did not achieve a consensus, but two interviewees agreed that this concept was not referenced, while one said, again, that it could be abstracted based on their experience and other said it was clear. Finally, all interviewees agreed that the stakeholder was an essential part of our approach and that it should be considered.

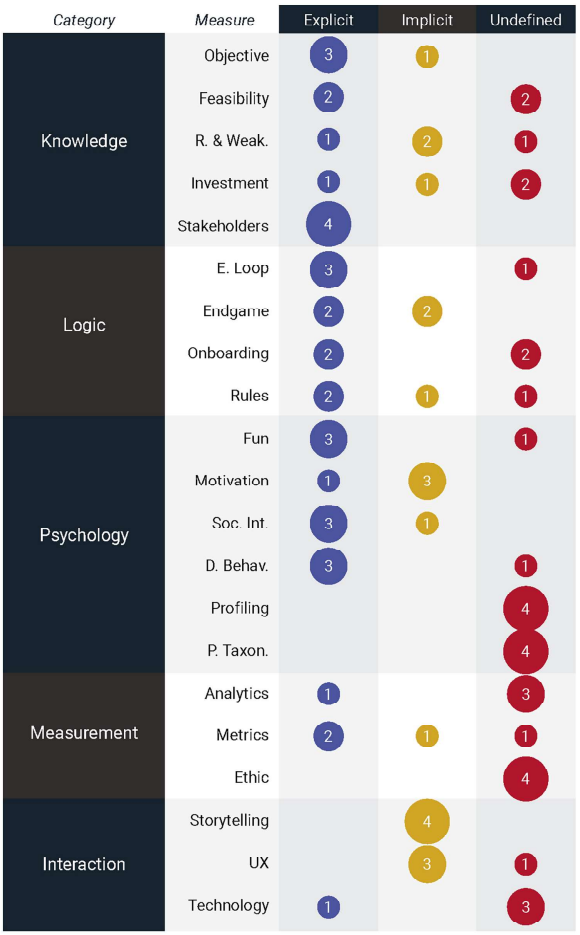

Fig. 3. Evaluation performed by the experts.

After answering those questions, the experts could make any comments they desired. One of them said that the documentation was very brief and could not provide all the information that was analyzed. Other expert said the documentation could be improved by adding more details regarding each sub-step.

4.1.2. Logic

The engagement loop was considered an explicit item in our documentation to 3 out of 4 experts (75%). However, the other experts explained that they did not consider our game elements as part of the engagement loop, answering that it was not referenced. As for the end-game, all the experts agreed that they were presented in our approach. However, half considered as an explicit concept in the documentation and the other half consider it implicit. According to the interviewees that answered the concept as being implicit, the end-game should be present at the end of the instructional activities, since those activities always contain an end. The onboarding did not achieve a consensus, with half of the interviewees considered it something explicit (due to the sub-phase in Step 3), and the other half considered it unreferenced, explaining that this phase cannot be considered an on-boarding process. Finally, 3 experts considered that our approach contained rules, with two saying that those rules were explicit and one saying it was implicit in the game mechanics. One of the interviewees did not find the rules concept.

Regarding the logic item, one of the gamification experts criticized the fact that our approach was heavily based on game mechanics rather than other important factors that should be addressed by gamification. Two of the interviewees also suggested that each strategy should be addressed with the intended behavior they were designed for. Finally, one of the gamification experts asked to improve the description of the game elements in the documentation.

4.1.3. Psychology

Psychology was the item with the highest level of agreement between the interviewees. Regarding the Fun item, 3 out of 4 interviewees considered its approach explicit enough, since gamification has the goal to make the tasks more fun. However, one of the gamification experts stated that the concept was not referenced in the documentation in the same way as it was written. Motivation achieved a full level of agreement among the experts. However, 3 out of 4 of them have stated that they considered it an implicit concept due to the gamified strategies being based on a motivational theory. All the experts agreed on the presence of Social Interaction in our approach, although one of the gamification experts stated it was implicit in the game elements. Desired behavior was considered an explicit item in our documentation. However, one gamification expert stated that the desired behavior should be connected to the gamification strategies, as they were not referenced enough in his opinion. All the experts agreed that our approach did not consider Profiling or Player Taxonomies.

Regarding the interviewees responses covering this specific group of items, we believe that our approach needs to be improved regarding its documentation. We also want to add profiling and player taxonomies to our approach, since they are important factors that are not contemplated yet.

4.1.4. Measurements

In this group of items, the experts achieved a full agreement regarding the Analytics and Ethics items. According to them, the items were not referenced in our documentation. As for the metrics, the experts did not achieve a consensus. 3 out of 4 believed that our documentation explained the metrics, in an explicit or implicit fashion. One of the interviewees said this concept was not well covered in our documentation.

The comments regarding the Measurements were suggestions on how it could be improved the approach by collecting the data for analytics. Another suggestion was to improve the documentation regarding what could be measured and how it should be measured. The ethics item, although not referenced, did not have any comments.

4.1.5. Interactions

The last group of items also had a considerable level of agreement among the interviewees. All the experts agreed that Storytelling was implicit in our approach, due to the narrative game element. However, two of them stated that the description and explanation of how to use it should be improved. Regarding the UX (user experience), 3 out of 4 found it an implicit concept, and one considered lacking references. The comment regarding this topic was directly affected by the lack of tools aiding in the process. Finally, 3 out of 4 experts agreed that our approach did not referenced any technology, while the other one stated that this concept was indeed explicit, due to the need for social networks.

In general, all the experts praised how easy it was to understand the approach, although some of the experts stated that this also made the documentation very difficult to understand and that it should be improved and detailed.

4.2. Case study

To instance our approach, we conducted a descriptive case study within a programming lesson of an undergraduate course in computer science (Toda et al., 2018). This case study was based on the concepts defined by Yin (2009), where we aim to explore the instance of GAMIFY-SN in a real context. To guide our case study, we defined the following research question “How does GAMIFY-SN impact a real educational context?” followed by “Does the gamified tasks pleases the

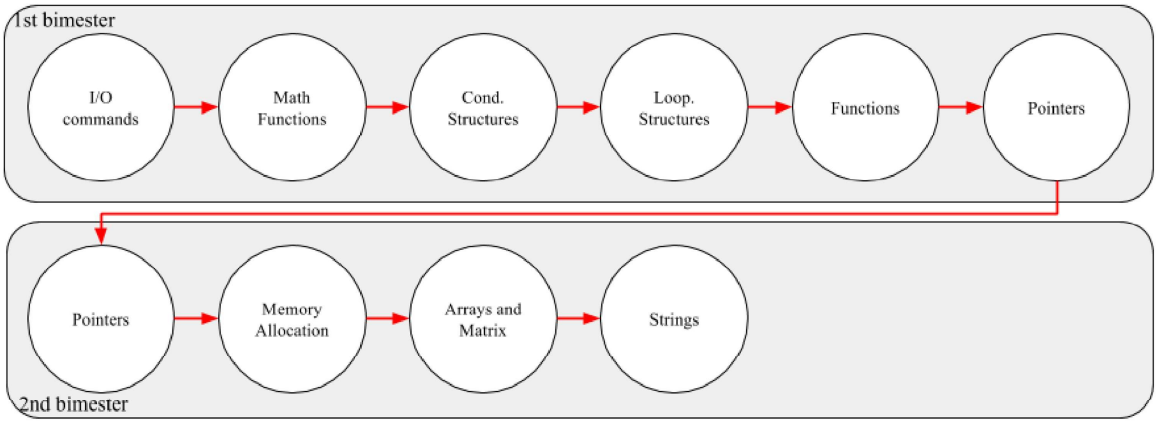

Fig. 4. Structure as seen on Toda et al. (2018).

students and instructors?" through a quantitative and qualitative viewpoint.

To instance our case study, we asked an instructor to instance our approach. Next, the classroom environment was chosen according to the instructor's choice and the instructional material that was available. The class consisted of 40 students, from an age group of 18–24 years old. The researchers were available anytime the instructor needed any support with the approach and within the classes to take notes. The researchers took notes during the Implantation phase and interviewed some students ($n = 20$) to obtain their feedback. The approach was instanced through a programming lesson course that lasted one semester and the researchers developed a questionnaire of 15 questions, with 3 different dimensions: Social network frequency; Gamification elements acceptance; and Instructor Influence in the approach. Six questions aimed to evaluate the frequency and use of social network, five to evaluate the gamification elements that were used and four to evaluate the instructor influence. The questions were based on a Likert scale, varying from 1 to 5, where 1 was "I fully disagree"_ and 5 was "I fully agree"_.

Findings from the case study

Initially, the instructor had access to the documentation of the approach and a meeting with the researchers to deploy it. To conduct our study, the existing approaches were modified and merged (Mesquita, Toda, Brancher, & do Carmo, 2013; Toda et al., 2016) to systematically plan and deploy gamification concepts with social networks in a classroom context. To achieve this goal, the professor was helped to analyze the structure of the course to create a representation of it. The instructional resources that were available were lesson plans which were developed to use Social Network concepts to aid in the teaching of the concepts related to programming. Those lesson plans followed a traditional approach with in-class lectures and task lists to exercise the concepts that were taught. The structure demonstrated a direct flow chart behavior where the first node was the Input and Output commands, and the last was the String commands (Fig. 4). The "pointers" concept was explained twice in this flow chart due to time restraints that hindered the teacher do finish the content before the end of the first part of the course.

After creating the representation shown in Fig. 4, the instructor selected a social network (Facebook[1]) that contained forums, message exchanges and status updates as main features. The social network also allowed to upload and download files from the course. Finally, the instructor aimed to make the students understand those concepts as the desired behavior, focusing on their performance. Then, based on the analysis of the instructional resources of the course, we started the development of the gamified tasks. Each instructional task that was associated to a content went through the Definition of the Gamified Task (as seen on Fig. 2). The main objective of the tasks was for the students to understand the concepts and to perform the programming exercises applied to them. These exercises, together with all communication between students and instructors, were made through a social network. An example of a gamified task that was created can be seen on Fig. 5. Examples on how to apply the game elements within tasks can be seen on the section **"Definition of the Game elements"** in the document presented in Section 3.2. In this example, after the analysis of the structure that was defined by the teacher and discussed with the researchers, there was a task named "Exercise the concept of input and output commands". Based on the researchers' background, they suggest the use of Points and Levels as feedback elements and Competition and Cooperation as property elements. Then, they defined the strategies "Give Points", "Accumulate points" and linked them with the properties "Help a student" (Cooperation) and "First who gets the question right" (Competition).

Before the gamified tasks began, the students were asked if they wanted to participate in the gamified course or the traditional one (with lessons, exercises, and tests). The students that opted for not taking part in the gamified course were not accounted for in the interviews and observation phase. This competition was based on the tasks given by the instructor. Each task contained a specific number of points that was given to the first student that completed it properly. When the students reached a predetermined number of points they would increase their level and acquire new skills that could be used to solve the tasks that were given. This level would be converted in the student's final grade at the end of the course. The students could keep track of their progress through a leaderboard in the forum that was updated after every class. Other gamified tasks were generated, but only added experience points to the student's current amount of experience, as the frequency of the course and participation. The incentives were given to improve their behaviors within the class. The practice was supported and conducted through the social network. After defining the gamified tasks, we began the Deployment phase.

During the Deployment phase, it was noticed that some students presented some level of enthusiasm and an increase in their participation in the classes and forum. This online participation increased during the days that the tasks were given, since the students asked for help or submitted tips on how to solve the problems. During the observation, a group of students was interviewed ($n = 20$) to generate a feedback on the core gamified task dynamics. Through this interview some problems regarding the students during the course were identified:

- They were not pleased with the competition dynamics, since only the first student answering correctly would obtain the points.
- They complained about the number and difficulty of the tasks.

[1] http://www.facebook.com

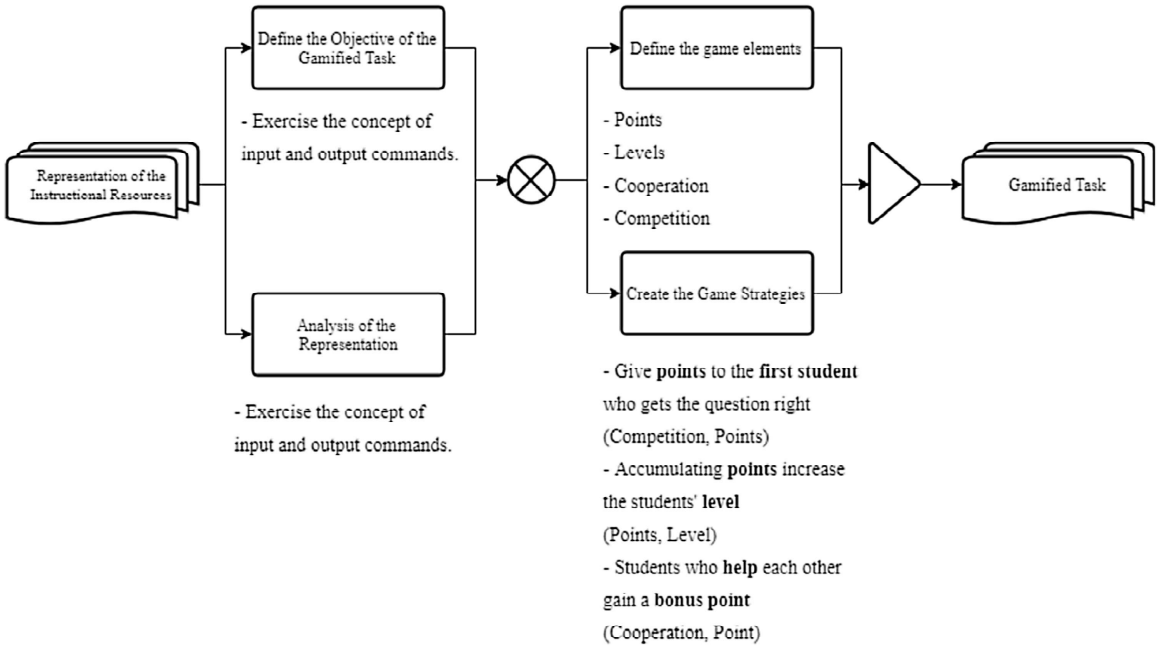

Fig. 5. Definition of a Gamified Task example.

- They were pleased with the use of the social network to exchange messages with the instructors.
- They were pleased with the progress representation but not with the leaderboard that was shown to every student in the class.
- They perceived/felt that they were learning more/having a better performance because of the progress representation.

After the Deployment phase, we began the Evaluation phase. The instructors wanted to evaluate the performance and engagement of the students during the course. They performed (qualitative) interviews with the students and asked them to answer a self-evaluation questionnaire to understand how the students perceived their performance, after the gamified course. According to the instructors, the student's grades improved in relation to past lessons. However, we cannot affirm with certainty that the students' grades were influenced or related to our approach since this was not a focus of the work.

Next, our questionnaire composed of 15 questions was applied after the final evaluation, to minimize the bias in the student's responses. Most of the students were pleased with the gamified course, obtaining an average of 3.5, especially with the experience points system that obtained an average of 4.02. A summary of our results can be observed in Fig. 4. The statistics demonstrate that the gamification was well accepted by the students, especially the progression system. Regarding the social network, students reported that they increased the access on the study group during the gamified experience, and socialized more with their peers, to help them in solving the problems that were given.

The most important results were the instructors' influence in the gamified activity. The students evaluated the following points in the questionnaire: the instructor's feedback, that was given when the exercises were delivered; the instructor's incentive, that was given through the social network and during classes to encourage the resolution of problems; the instructor's interference within the gamified task, with specific potential changes in the rules or mechanics during the tasks that were given; and the instructor's explanation of the rules, performed every time a new task was given.

Students also reported that the feedback and instructions were crucial to their satisfaction of the gamified task (Fig. 6). The students also stated that the social network gained a new meaning in their academic life and started to use the community to exchange materials and tasks from other subjects. We identified some correlations (ρ) among our variables. Using Pearson's correlation coefficient, we identified that the progression system of gamification was well accepted by students due to the instructor's feedback ($\rho = 0.74$) and instructions ($\rho = 0.71$). The progression was also well accepted by students that liked the level system ($\rho = 0.76$). This result may imply that to have a well-accepted progression mechanic, the instructor's instructions and feedback must be present, e.g. the instant feedback that the students received when submitting the exercises and the instructions given by the instructors before every gamified activity. In our sample, a higher coefficient values for the instructor's variables was found. According to our data, the instructor's instructions, incentive and feedback are strongly related ($\rho > 0.7$). This may imply that to have a good gamification, the instructor must be an active part of the process, explaining the rules, giving instantaneous feedback and encouraging participation.

To analyze the point of view of the instructors, interviews to understand the planning and implantation phase were performed. The instructors stated that the gamified core task was fun, and the social network community was a good tool to improve communication between them and the students. However, they found it very laborious. Due to the game elements that were chosen, a student would have to deliver 4 tasks, which means that they needed to perform up to 40 exercises to reach the maximum level (10). In other words, they would need to solve a total of 1600 to reach the maximum level. To reduce the workload, some rules and mechanics were modified, as well as the number of students per group and the experience points of the questions, to give chance to every student to reach the maximum level.

Another point focused by the instructors was the automation of the process, helping them to choose the elements and strategies to be used, without the physical need for the gamification expert. They also stated that even though the experience was fun and engaging, it took a lot of time to plan and to manage. In summary, three main obstacles were reported by the instructors: planning the resources, automation of the process and time and corroborating the results found by the literature (Martí-Parreño et al., 2016; Sánchez-Mena & Martí-Parreño, 2016).

5. Discussion, practical implications and conclusions

Based on our results, we believe that our approach can aid in the planning of gamification in classroom environments using web technologies (as SNS) to improve the students' experience. Based on the

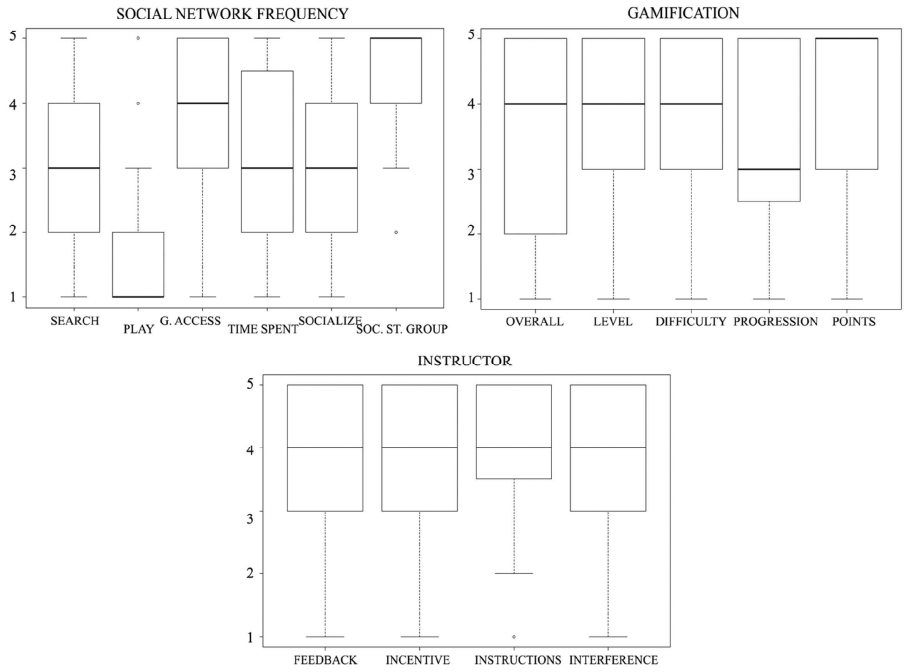

Fig. 6. Box plot of the results.

comments provided by the specialists, we understand that our approach lack some of important aspects to be considered within gamification. On the other hand, those aspects were not mentioned by the instructor that used the approach, during the interview, and the results of our case study demonstrated a good acceptance by the students and the instructors. The instructor's comments on the approach were crucial to understand the flaws to improve it in the next iterations. As for practical implications, we believe the difficulty of managing the gamification that is planned can be related to the number of elements used within the context. However, this topic is out of the scope of this project (which aims at aiding the instructor) but can be explored in future studies.

In this work, we focused on explaining the guidelines, application and analysis of the GAMIFY-SN approach. The guidelines presented in this work can help the instructors and teachers to plan and deploy gamification with social networks within their lectures, requiring only instructional resources. Our results proved the success of the Gamified Task that was implanted within the social network environment, corroborating the results found in De-Marcos et al. (2015). Another result of this work is the strategy that can be replicated in other programming courses that follow the same curricula. Finally, we provide some insights on the instructor's point of view of the design and implantation of the gamification process, which is not well reported in the literature. Based on what was exposed we believe that some of the contributions of this work are:

- The approach that support gamification planning and deployment.
- Empirical evidence on the use of this approach.
- Validation of the documentation by specialists.
- Summarization of strategies that can be used within educational contexts, especially in classroom contexts.

A practical challenge of our work is how to automate the process to ease the task or even exclude the game designer, so the instructor can use the gamification without the aid of a game designer and without having to know everything that is related to game studies and gamification. We believe that by using data-driven gamification we can minimize the presence of the game designer, by using data of other gamified studies or contained within gamified systems to generate strategies that can be easily read and understood by the instructor.

Some limitations of our case study include the technical problems in the deployment phase, where the number of exercises was not previously considered in the planning. Another limitation is an evaluation that focused mainly on the reports of the students and the point of view of the instructors and their motivation, engagement and performance was not properly evaluated and discussed in this work. Finally, the analysis was performed by the experts, based on the documentation and guidelines of the approach; however, since there is no valid tool to evaluate, we conducted our analysis based on a previous one that was performed by Mora et al. (2017), in which they interviewed the experts and asked if the approach contained each of the items that were proposed for the assessment. For future works, we intend to model a macro process that will contain all the features collected by Mora et al. (2017), also integrating features from other gamification approaches. We also intend to formalize the assessment of the framework by applying a valid tool to measure each of the items that were proposed. Finally, we intend to perform a deeper investigation regarding the point of view of the instructors, to collect requirements to implement a tool to automate this process, allowing the instructors to author their own gamified strategies.

Acknowledgments

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Appendix A. Game elements strategy

Table 2
Game elements strategy.

	Element	Description (As seen in Dignan, 2011; Mesquita et al., 2013)	Strategy	Example
Feedback	Points	A token granted for measuring users' actions	Give points to the students that post relevant comments on the SN	Mesquita et al. (2013)
			Give points to students that submitt the work	Hakulinen and Auvinen (2014)
	Reputation	Represent the hierarchy of a game community, through titles or leaderboards	Use leaderboards to measure students' performance	Mesquita et al. (2013)
			Use anonymous leaderboards, allowing the students' to assess their own performance	Iosup and Epema (2014)
	Achievements	Fixed goals or objectives that measure degrees of success of user's actions	Use milestones as the content, to boost self-worth and user's satisfaction	Bunchball (2010)
	Progress	Form of feedback that allow the user to assess their own progress	Use progress bars or progress boards to show student's development through the class	Mesquita et al. (2013)
			Use individual progress maps and collective progress maps	Toda et al. (2016)
	Level	Form of hierarchy layers related to the game domain, that also can be used as gradual systems	Use accumulative points to give levels to the students, incentiving them to play, achieve and excel	Iosup and Epema (2014)
			Use layers of content to use levels as a form of progress	Toda et al. (2018)
	Trophies	Represent the recognition for the user's actions	Give badges to the students that achieve a certain level	Bunchball (2010)
			Give badges to students that answer properly questions in class	Iosup and Epema (2014)
Property	Cooperation	Occur when two or more players work as a team towards a common goal	Create teams to engage students in teamwork	Iosup and Epema (2014)
			Make teams to produce and compare resources among themselves in order to improve it	Müller, Reise, and Seliger (2015)
	Competition	Occurs when two or more players engage among themselves towards a common goal	Create a challenge to make the students compete among themselves in order to acquire knowledge	de Sousa Monteiro, Gomes, and Mendes Neto (2014)
			Create teams and make them compete among themselves	Passos and Medeiros (2011)
	Renovation	Occurs when the user is allowed to re-do an action	Allow the student to re-do a task or activity	Lee and Hammer (2011)
	Narrative	Occurs when the designer create a background to contextualize the user outside its reality	Create a storyline to join multiple levels	Bell, Sheth, and Kaiser (2011)
			Create a storyline that allows the students to form groups and discuss with their peers their next actions	Sung and Hwang (2013)
	Pressure	Occurs when time or social interactions are used as means to engage the user to perform an action	Give badges to students that complete a task within a limited time	Hakulinen and Auvinen (2014) and Kapp (2012)
			Promote competition among teams with a limited time	Toda et al. (2016)
	Economy	Occurs when there is an element that is used to perform transactions between users	Give points that the students can exchange for vantages during classes	Toda et al. (2016)
			Give points that the student can exchange for items within an environment	Kim, Park, and Baek (2009)
	Decision	Occurs when the user is presented with choices that will affect their experience	Provide the student with the ability to decide when to deliver a task	Lee and Hammer (2011)
	Puzzle	Occurs when cognitive challenges are used to satisfy the user's internal needs of problem solving	Provide students with challenges that stimulate their cognition	Kapp (2012)
	Chance	Occurs when the same opportunity is offered to all the users	Provide the students the same kinds of feedback independent of hierarchy or class	Mesquita et al. (2013)
	Secret	Occurs when there is hidden or unlockable content that can be accessed by the user	Provide the students with currency that can be used to unlock content as they progress	Raymer (2011)
			Unlock content as the student accumulates experience or badges	Challco, Mizoguchi, and Isotani (2016)
	Novelty	Occurs when new information and experience are presented to the user, as it progress	Present the content in a hierarchically, so that students can understand it in a logical way	Mesquita et al. (2013)
	Randomness	Occurs when probability is inserted, being affected exclusively by the user's luck	Provide the student with lottery tickets to gain vantages during tests in class	Toda et al. (2016)

References

Araújo, J., & Pestana, G. (2017). A framework for social well-being and skills management at the workplace. *International Journal of Information Management, 37*, 718–725.

Bell, J., Sheth, S., & Kaiser, G. (2011). *Secret ninja testing with HALO software engineering. Proceedings of the 4th international workshop on social software engineering – SSE '11.* New York, New York, USA: ACM Press43–47.

Borges, S.d. S., Durelli, V. H. S., Reis, H. M., & Isotani, S. (2014). A systematic mapping on gamification applied to education. *Proceedings of the 29th annual ACM symposium on applied computing – SAC '14* (pp. 216–222).

Boyd, D. M., & Ellison, N. B. (2007). Social network sites: Definition, history, and scholarship. *Journal of Computer-Mediated Communication, 13*, 210–230.

Bunchball (2010). *Gamification 101: An introduction to the use of game dynamics to influence behavior*.

Challco, G. C., Mizoguchi, R., & Isotani, S. (2016). An ontology framework to apply gamification in CSCL scenarios as persuasive technology. *Revista Brasileira de Informática na Educação, 24*, 67–76.

Chang, V. (2016). Review and discussion: E-learning for academia and industry. *International Journal of Information Management, 36*, 476–485.

de Sousa Monteiro, B., Gomes, A. S., & Mendes Neto, F. M. (2014). Youubi: Open software for ubiquitous learning. *Computers in Human Behavior, 55*, 1145–1164.

De-Marcos, L., Garcia-Lopez, E., & Garcia-Cabot, A. (2015). On the effectiveness of game-like and social approaches in learning: Comparing educational gaming, gamification & social networking. *Computers & Education, 95*, 99–113.

Dichev, C., & Dicheva, D. (2017). Gamifying education: What is known, what is believed and what remains uncertain: A critical review. *International Journal of Educational Technology in Higher Education, 14* 36p.

DiCicco-Bloom, B., & Crabtree, B. F. (2006). The qualitative research interview. *Medical Education, 40*, 314–321.

Dignan, A. (2011). *Game frame.* Free Press.

Hakulinen, L., & Auvinen, T. (2014). The effect of gamification on students with different achievement goal orientations. *2014 international conference on teaching and learning in computing and engineering,* 9–16.

Hamari, J., & Keronen, L. (2017). Why do people play games? A meta-analysis. *International Journal of Information Management, 37*, 125–141.

Hamari, J., & Koivisto, J. (2015). Why do people use gamification services? *International Journal of Information Management, 35*, 419–431.

Iosup, A., & Epema, D. (2014). *An experience report on using gamification in technical higher education. Proceedings of the 45th ACM technical symposium on computer science education – SIGCSE '14, 2008.* New York, New York, USA: ACM Press27–32.

Kapp, K. M. (2012). *The gamification of learning and instruction: Game-based methods and strategies for training and education.*

Kim, B., Park, H., & Baek, Y. (2009). Not just fun, but serious strategies: Using meta-cognitive strategies in game-based learning. *Computers & Education, 52*, 800–810.

Klock, A. C. T., da Cunha, L. F., de Carvalho, M. F., Rosa, B. E., Anton, A. J., & Gasparini, I. (2015). *Gamification in e-learning systems: A conceptual model to engage students and its application in an adaptive e-learning system. Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics), volume 9192.* Cham: Springer595–607.

Lee, J. J., & Hammer, J. (2011). Gamification in education: What, how, why bother? *Academic Exchange Quarterly, 15*, 1–5.

Lim, H., Lee, S. G., & Nam, K. (2007). Validating E-learning factors affecting training effectiveness. *International Journal of Information Management, 27*, 22–35.

Marczewski, A. (2015). *Even ninja monkeys like to play: Gamification, game thinking and motivational design.* Gamified UK.

Martí-Parreño, J., Seguí-Mas, D., & Seguí-Mas, E. (2016). Teachers' attitude towards and actual use of gamification. *Procedia – Social and Behavioral Sciences, 228*, 682–688.

Mesquita, M., Toda, A., Brancher, J., & do Carmo, R. (2013). Utilizing gamification concepts tied with social networks to support students in programming classes. *Proceedings of the XV Simpósio Internacional de Informática Educativa,* 127–132.

Mora, A., Riera, D., González, C., & Arnedo-Moreno, J. (2017). Gamification: A systematic review of design frameworks. *Journal of Computing in Higher Education,* 516–548.

Müller, B. C., Reise, C., & Seliger, G. (2015). Gamification in factory management education - A case study with Lego Mindstorms. *Procedia CIRP 26,* 121–126.

Opdenakker, R. (2006). Advantages and disadvantages of four interview techniques in qualitative research. *Forum Qualitative Sozialforschung, 7*, 13.

Paiva, R., Bittencourt, I. I., Tenório, T., Jaques, P., & Isotani, S. (2016). What do students do on-line? Modeling students' interactions to improve their learning experience. *Computers in Human Behavior, 64*, 769–781.

Parikh, M., & Verma, S. (2002). Utilizing Internet technologies to support learning: An empirical analysis. *International Journal of Information Management, 22*, 27–46.

Passos, E., & Medeiros, D. (2011). Turning real-world software development into a game. *2011 Brazilian symposium on games and digital entertainment (SBGAMES)*.

Raymer, R. (2011). Gamification: Using game mechanics to enhance eLearning. *Elearn Magazine*.

Sánchez-Mena, A., & Martí-Parreño, J. (2016). Gamification in higher education: Teachers' drivers and barriers. *Proceedings of the international conference of the future of education*.

Sung, H.-Y., & Hwang, G.-J. (2013). A collaborative game-based learning approach to improving students' learning performance in science courses. *Computers & Education, 63*, 43–51.

Tenório, T., Bittencourt, I. I., Isotani, S., Pedro, A., & Ospina, P. (2016). A gamified peer assessment model for on-line learning environments in a competitive context. *Computers in Human Behavior, 64*, 247–263.

Thom, J., Millen, D., & DiMicco, J. (2012). Removing gamification from an enterprise SNS. *Proceedings of the ACM 2012 conference on computer supported cooperative work,* 1067–1070.

Toda, A. M., do Carmo, R. M. C., da Silva, A. P., & Isotani, S. (2018). GAMIFY-SN: A metamodel for planning and deploying gamification concepts within social networks – A case study. In Á. Rocha, H. Adeli, L. P. Reis, & S. Costanzo (Eds.). *Trends and advances in information systems and technologies* (pp. 1357–1366). Cham: Springer International Publishing.

Toda, A., Silva, Y., Cruz, W., Xavier, L., & Isotani, S. (2016). Um processo de Gamificação para o ensino superior: Experiências em um módulo de Bioquímica. *Anais do Workshop de Informática na Escola, Vol. 22,* 495–504.

Werbach, K., & Hunter, D. (2012). *For the win: How game thinking can revolutionize your business.* Wharton Digital Press.

Wongso, O., Rosmansyah, Y., & Bandung, Y. (2014). Gamification framework model, based on social engagement in e-learning 2.0. *2014 2nd international conference on technology, informatics, management, engineering, and environment (TIME-E),* 10–14.

Yin, R. K. (2009). *Case study research: Design and methods, Vol. 5.* Sage Publications.

Zichermann, G., & Cunningham, C. (2011). *Gamification by design: Implementing game mechanics in web and mobile apps* (1 edition). O'Reilly Media.

ANNEX

I

ANALYSING GAMIFICATION ELEMENTS IN EDUCATIONAL ENVIRONMENTS USING AN EXISTING GAMIFICATION TAXONOMY

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Analysing gamification elements in educational environments using an existing Gamification taxonomy

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Abstract

Gamification has been widely employed in the educational domain over the past eight years when the term became a trend. However, the literature states that gamification still lacks formal definitions to support the design and analysis of gamified strategies. This paper analysed the game elements employed in gamified learning environments through a previously proposed and evaluated taxonomy while detailing and expanding this taxonomy. In the current paper, we describe our taxonomy in-depth as well as expand it. Our new structured results demonstrate an extension of the proposed taxonomy which results from this process, is divided into five dimensions, related to the learner and the learning environment. Our main contribution is the detailed taxonomy that can be used to design and evaluate gamification design in learning environments.

Introduction

Gamification has been extensively used in educational environments and instructional practices (Dichev and Dicheva 2017) to enhance students' engagement and motivation through the employment of game design elements outside of a fully-fledged game (Barata et al. 2015; Deterding et al. 2011; Kapp 2012; Nand et al. 2019). While recognizing the available game elements and choosing which of them must be employed in gamified environments are not trivial tasks, some gamification frameworks are aiming to help designers with that. However, many of these frameworks have no common understanding of the set of game elements that can be used by gamified systems and the knowledge on how to apply them. (Dichev and Dicheva 2017; Klock et al. 2018b; Mora et al. 2015; Toda et al. 2018b). Besides, there are no naming conventions and the process to support which elements belong to gamification are other issues found in gamification literature in general, as they use different synonyms for the same game element, e.g., badges and trophies (Koivisto and Hamari 2019; Pedreira et al. 2015; Seaborn and Fels 2014).

All these hinder the adoption of gamification by teachers and instructors, since recent studies demonstrated that these specialists have interest in using gamification but does not have time or resources to make sense of differences and similarities in deciding which game elements to use, as well as which game elements are more

appropriate in educational context (Martí-Parreño et al. 2016; Sánchez-Mena and Martí-Parreño 2016; Toda et al. 2018a). Aiming to solve this problem, an initial taxonomy of game elements for gamified educational environments was proposed and evaluated [omitted for blind review]. We defined a poll of 21 game elements, alongside their synonyms, and validated them through two surveys with experts in the field of gamification in education. However, the initial taxonomy did not present how these elements could be grouped and organised in a way that could guide researchers, designers and instructors to use them more efficiently. Here, as an extension of a previous study, we propose to answer a more practical research question *"How can we use the proposed taxonomy to analyse and evaluate gamified educational environments?"*. By answering this research question, our contributions include:

- improving the existing taxonomy, by providing details on the selection, description, and use of these elements to evaluate and analyse existing systems;
- proposing recommendations on how to hierarchically organise these elements semantically, to be used by designers, teachers, and other education stakeholders.

Related works

Gamification frameworks are not a novelty nowadays, and recent literature reviews have mapped more than 50 frameworks focused on how to design gamification in a specific or broad context (Azouz and Lefdaoui 2018; Mora et al. 2017). However, only a few of them were focused on education and learning contexts (less than 10). Following the nomenclature issue previously described, these frameworks proposed different concepts with similar descriptions: while "a title attributed to the player that he can use to compare with others" is called *Social Status* by Marczewski (2015), it is a *Classification* in Dignan (2011). In this section, we present some existing taxonomies based on their adoption and the context of the framework/taxonomy.

Concerned with general contexts, which are frameworks that were created for general purposes, we have the taxonomy proposed in six steps to gamification (6D) (Werbach and Hunter 2012) presenting a hierarchy of game elements using Dynamics, Mechanics and Components, based on the MDA framework (Hunicke et al. 2004). In this classification, the top of the hierarchy is composed of the Dynamics, which are the abstractions related to the task that is being gamified. These Dynamics used to create the motivation to perform the task and are manifested via Mechanics. The Mechanics are the processes used to drive the users' actions and are presented through the Components. Finally, these components are extrinsic rewards and feedback features like points, badges, etc. The taxonomy presented in the 6D framework, however, does not provide the user with clear strategies on how to combine these elements properly. Also, being a general framework, it lacks instances on educational environments, validated empirically.

Next, we have the GAME framework (Marczewski 2015) which provides an extensive periodic table of gamification elements ($n = 52$). Their taxonomy is divided by player profiles ($n = 8$), where these elements may work better based on the users' player profile. In this framework, we can already observe some similarities with the concepts proposed in Werbach. In the GAME framework, the Progress/Feedback is treated as a

component that may engage general contexts, while in the 6D Progress is treated as a dynamic and Feedback as a Mechanic.

As for the frameworks used in the educational context, we opted to choose recent ones that were instanced.[1] The framework proposed by Klock et al. (2016) consists of 7 steps to aid the design of adaptive gamification in e-learning environments. In this framework, the authors use a set of 14 gamification elements based on 6D and apply it to develop an adaptive e-learning system. Another recent taxonomy is presented in the work of Toda et al. (2018a) where the authors propose a framework focused on teachers and instructors. The game elements in this work are divided into Feedback and Property. The Feedback elements are the ones that can be used as feedback, and the Property is characteristics and objectives for the educational task. The authors define a poll of 19 gamification elements and provide some strategies (based on existing literature) on their use. However, both taxonomies were not validated.

Finally, none of the taxonomies that were presented explicit ways on how to analyse those elements in learning environments nor how to analyse these elements. An overview can be seen in Table 1.

Methods and tools

As explained in [**omitted for blind review**], the game elements were collected, analysed and defined by the authors, then evaluated by gamification experts.[2] The collection was based on a literature review made by the authors, where they analysed the nomenclature of other gamification frameworks and analysed the concepts that were presented. Based on semantic analysis, we defined a set of 21 gamification elements that could be used in educational systems. After the initial definition, we designed an evaluation focusing on five variables:

- **Comprehensibility**: the standardised concept for the group of game elements, the "name".
- **Description**: the concept definition.
- **Relevance**: the relevance of that element in the overall taxonomy.
- **Examples**: the examples tied to the definition and concept.
- **Coverage**: the representation of the overall taxonomy. If this set of 21 elements represent and cover well the game elements needed for educational applications.

In this paper, we focus on expanding the descriptions of the gamification elements that were presented, and choose some existing gamified educational environments, based on their popularity and presence in research papers, to analyse these elements have been applied and interpret why, since this can be used to support designers to select the most appropriate game elements in their environments. The use of the taxonomy to support the process of analysis and evaluation was supervised by five gamification experts, that would analyse the systems and match with the elements in our taxonomy.

[1] By instanced, we mean that they were applied and evaluated in a real educational context
[2] Most of the experts were also teachers and researchers

Table 1 Related works comparison

Taxonomy	Field	Focus	Number of elements	Present Instances	Validation
Werbach and Hunter (2013)	General	Design	30	No	No
Marczewski (2015)	General	Design	52	No	No
Klock et al. (2016)	Education	Design	14	Yes	No
Toda et al. (2018a)	Education	Design	19	Yes	No
Actual Taxonomy	Education	Design, analysis and evaluation	21	Yes	Yes

Following, we focused on expanding the concepts, by giving examples of how these elements are represented in the literature, as well as advantages and disadvantages in employing them. Finally, we proposed a new hierarchical classification for these elements, that can support designers and developers to choose which elements to use in the make of gamified strategies.[3] This classification was designed starting by identifying five dimensions, each one associated with an aspect of the environment. To design these dimensions, the concepts were analysed on a semantic level and discussed amongst at least five researchers. The complete process can be seen in Fig. 1.

Results

This section describes the definitions of the taxonomy, some synonyms, and examples of how each element can be applied in an educational environment and some advantages and disadvantages in its use. We also propose an initial definition of extrinsic (when an element is presented in a way that the user can perceive it clearly and objectively) and intrinsic elements (which is an element presented in a subtle way that the user may not notice when interacting with the environment). An overall of the new taxonomy can be seen in Fig. 2.

Description of the five dimensions

Extending the initial taxonomy, we propose a classification using five dimensions to group the previously defined gamification elements. Each element was analysed by at least five experts to group each in the appropriate dimension, e.g.: *When analysing the Point element, the experts noticed that it was an extrinsic feedback element, that is given when the learner executes a certain action within the environment. Since it is given to the learner as a form of feedback, it would be appropriate to classify it as part of the Performance/Measurement dimension.* We describe the dimensions as follows.

Performance / measurement

These are elements related to the environment response, which can be used to provide feedback to the learner. In this dimension we have Point, Progression, Level, Stats and Acknowledgement. Lack of this dimension means that the student may feel disoriented as their actions does not have any kind of feedback.

[3] A Gamified strategy is a task, with a goal, that contains game-like elements (A. M. Toda, do Carmo, et al., 2018).

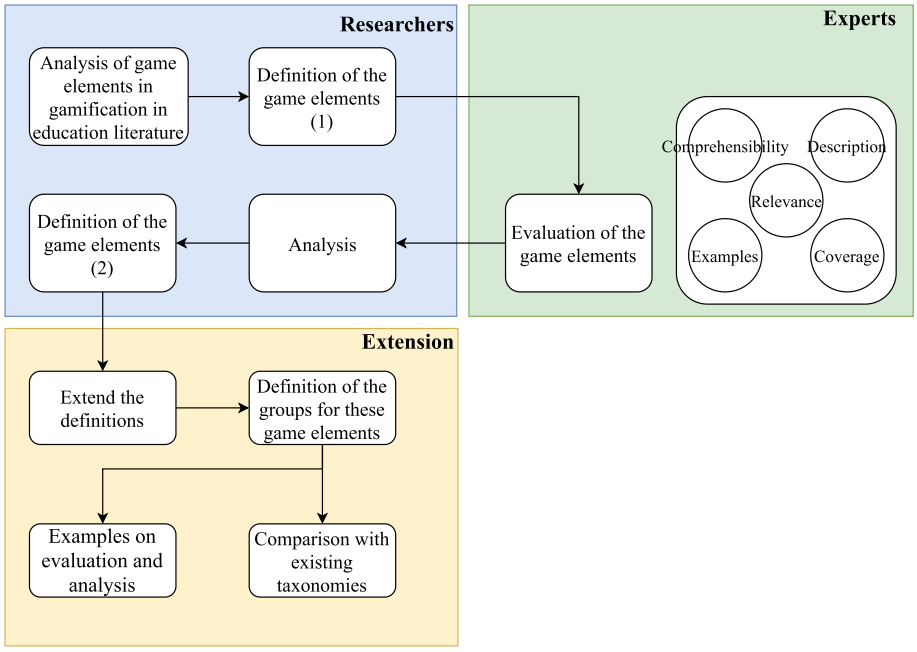

Fig. 1 Method adapted from Toda et al. (2019b) and the extension

- **Acknowledgement:** also known as badges, medals, trophies and achievements. It is a kind of extrinsic feedback that praises the players' specific set of actions, e.g. completing a certain number of problems may lead them to earn a "Solver" badge; finishing a task in a predefined time limit may earn them a "Flash" trophy; making a certain number of interactions with other students may give them a "Socialiser" achievement; making a certain number of contributions may earn them a "Contributor" badge. Acknowledgement is one of the most used elements in gamified applications (Klock et al. 2018a; Koivisto and Hamari 2019; Toda et al. 2018b).
- **Level:** also known as skill level, character level etc. This is related to an extrinsic hierarchical layer that provides the user new advantages as they advance in the environment, e.g. the students gain a level every time they complete a certain number of tasks, when they advance their level, they have access to more challenging tasks.
- **Progression**: also known as progress bars, steps, maps. Provides an extrinsic guidance to the users of their advance in the environment, allowing these users to locate themselves.
- **Point**: also known as scores, experience points, skill points, etc. It is a simple way to provide extrinsic feedback to the users' actions. Point is the most basic concept found in almost all gamified applications (Dichev and Dicheva 2017).
- **Stats:** also known as information, Head Up Display (HUD) and data. It is related to the visual information provided by the environment to the learner (extrinsic), e.g. how many tasks they completed or overall stats on the environment. In virtual environments this can also be dashboards.

Fig. 2 Gamification Taxonomy

Ecological

This context is related to the environment that the gamification is being implemented. These elements can be represented as properties. The elements in this dimension are Chance, Imposed Choice, Economy, Rarity and Time Pressure. The lack of Ecological elements makes the environment feel dull, as it does not have elements that produce interactions with the user.

- **Chance:** also known as randomness, luck, fortune or probability. This intrinsic concept is related to the random property of a certain event or outcome, e.g. the student may get a random number of points after completing a task; spinning a roulette that may give the user a bonus; user has a probability of getting a special item based on its luck (Dignan 2011).
- **Imposed choice:** also known as choice, judgment, and paths. This extrinsic concept occurs when the player faces an explicit decision that they must make to advance in the environment. An example of this concept is to present the user two different contents and make them choose one or another, blocking their advance if a choice is not to pick.
- **Economy:** also known as transactions, market, exchange. This concept is extrinsically related to any transaction that may occur in the environment.

Examples are trading points for advantages within the environment and related to the content.

- **Rarity**: also known as limited items, collection, exclusivity. It is related to extrinsically limited resources within the environment which can stimulate the learners through a specific goal.
- **Time Pressure:** also represented as countdown timers or clocks. It is related to time itself used to pressure the learners' actions (extrinsic). In learning environments, this can be represented also as deadlines. It is, alongside Social Pressure, considered one of the most irrelevant elements since it can potentially disengage the learner (Toda et al. 2019b).

Social

This dimension is related to the interactions between the learners presented in the environment. The elements in this dimension are Competition, Cooperation, Reputation, Social Pressure. The lack of Social elements can isolate the students, since they will not be able to interact with other students.

- **Competition:** also known as conflict, leader boards, scoreboards, player vs player, etc. It's an intrinsic concept, tied to a challenge where the user faces another user to achieve a common goal, e.g. using scoreboards based on the number of points, badges, levels, etc.
- **Cooperation**: also known as teamwork, co-op, groups, etc. It is also an intrinsic concept (related to a task) where the users must collaborate to achieve a common goal, can be considered the opposite of competition (however, both concepts can be used together). Examples of cooperation are tasks where groups interact with each other and are recognised by these interactions (Shi et al. 2014).
- **Reputation**: also known as classification, status. It is related to titles that the learner may gain and accumulate within the environment (intrinsic). Differing from levels, titles represent more of a social status which does not necessarily reflect on the learners' skills. These titles are usually used within communities to create a hierarchy in the environment.
- **Social Pressure:** Also known as peer pressure or guild missions. This intrinsic concept is related to social interactions that exert pressure on the learner.

Personal

This dimension is related to the learner that is using the environment. The elements that are used in this dimension are Sensation, Objective, Puzzle, Novelty, and Renovation. The lack of Personal elements can make the user feel demotivated since the system does not provide meaning for the student.

- **Novelty**: also known as an update, surprise, changes, etc. It is intrinsically related to the updates that occur within the environment, by adding new information, content or even new game elements. It is a good strategy to keep users within the environment to avoid stagnation since longitudinal studies on gamification have

shown that a static approach (without updates) may cause disengagement and demotivation (Hanus and Fox 2014).

- **Objectives:** also known as missions, side-quests, milestones, etc. This intrinsic concept is related to goals, it provides the player an end, or a purpose to perform the required tasks. Examples on the use of Objective can be broadened (as getting approved in the course) or more specific (as obtaining a certain score in a task) (Toda et al. 2018a).
- **Puzzle**: also known as challenges, cognitive tasks, actual puzzles, etc. This intrinsic concept is related to the activities that are implemented within the environment, they can be tied or considered as the learning activities since the focus is to provide a cognitive challenge to the learner. This concept is also implicitly present in all educational environments, through quizzes or challenges.
- **Renovation**: also known as boosts, extra life, renewal, etc. This concept is intrinsically related to the property of re-doing a task, event or any of the sorts. It allows the learner a second chance after they fail a task. It is one of the properties that makes games fun (Lee and Hammer 2011).
- **Sensation**: This is either visual or sound stimulation, etc. It is related to the use of learners' senses to improve the experience (intrinsic). This can be done through dynamic and gameful interfaces, Virtual Reality (VR) and/or Augmented Reality (AR).

Fictional

It is the mixed dimension that is related to the user (through Narrative) and the environment (through Storytelling), tying their experience with the context. The lack of Fictional elements causes the loss of meaning, of context, that is, the why, within the immersive environment, the user must perform any task, as well as directly influence the quality of the user experience.

- **Narrative:** also known as karma system, implicit decisions, etc. This intrinsic concept is the order of events as they happen in the game, through the user experience. This experience is influenced by implicit choices made by the user. Examples of this are giving a small token of appreciation to the students that opt to interact with other students, subtly and discreetly (Palomino et al. 2019).
- **Storytelling:** can be seen as audio queues, text stories, etc. It is the way the story of the environment is told (as a script). It is told through text, voice, or sensorial resources. It is highly used as a tool to support the narrative within an environment (Palomino et al. 2019).

Example on the use of the taxonomy

To demonstrate the analysis and evaluation of these elements, we choose some e-learning environments that are cited and evaluated in the literature (Klock et al. 2017) as Duolingo and MeuTutor. We opted initially for these two for: (a) one is one of the most successful examples of gamification in education and (b) the other due to convenience since we had access to all the functionalities of the system and its design process (convenience sampling).

Duolingo is one of the most famous language apps nowadays and most of its success is due to the gamification that was implemented. According to (Huynh et al. 2016) the main elements of Duolingo are Rewards, Leader-boards, Level-system, and Badges. When analysing these elements, we can observe that other elements from our taxonomy are presented, e.g. Rewards are represented through Lingots, which is a currency obtained when you finish a task. These Lingots can be used in the transaction in the system (**Economy**); the Leader-boards are used to create a **Competition** amongst the user and their friends. The Level-system contains four elements: experience points (**Point**), the content the user chooses when they are learning the language (**Imposed Choice**), the level they are in the language (**Progression**) and the user skills (**Level**). Finally, the Badges are a representation of **Acknowledgement** and can be used in the player profile to increase their **Reputation**. Besides these elements, we can observe all of the Personal dimension since the site appeals visually to the user (**Sensation**), providing them a clear **Objective** (learning languages), achieved through cognitive tasks (**Puzzles**), presenting new content (**Novelty**) and allowing them to redo any task as the user wants (**Renovation**).

By using our taxonomy, we can observe that Duolingo presents a solid Personal (All 5) and Measurement (4 elements) dimensions, some Ecological and Social aspects underneath the system (2 elements each) and no Fiction element.

Following, MeuTutor is an Intelligent Tutoring System used in more than 10 schools in Brazil. The system contains many gamification elements to improve learners' engagement and motivation. According to the description of the system, MeuTutor gamification is based on: learners' being exposed to learning resources and gaining experience points for their interactions **(Point)**, which is converted into the learners' **Level**. The content is presented similarly as Duolingo where the learner must choose a topic to continue using the system **(Imposed Choice)**. The learners' can see their progress in the course through a completion percentage **(Progression)** and gain badges based on their interactions **(Acknowledgement)**, these learners can also see an overall of their performance in a personalised dashboard **(Stats)**. The system also presents a leaderboard to create a **Competition** amongst its users and collaborative activities, where the learners can create groups to perform a task **(Cooperation)**. MeuTutor also presents all the elements in the Personal Dimension**,** since it has a clear **Objective** (improve learners' knowledge on a certain content), achieved through many learning tasks **(Puzzles)** that can be updated as the teacher desires **(Novelty)**. The system also allows the learner to re-do previous tasks (however this **Renovation** does not add to their experience points) and has an interface that is attractive to the final users **(Sensation)**.

Through our taxonomy, we can observe that MeuTutor contain a solid Personal and Measurement dimension (All 5 elements of each dimension), it also presents two elements from the Social dimension but does not explore their efficacy, and one element in the Ecological dimension. Also, no Fictional element is present in this environment.

Discussion

These new dimensions might provide a way to analyse and/or support the design of gamified learning environments. We can also assure that it is aligned with the agenda defined in (Koivisto and Hamari 2019) which states that gamification

studies should pay more attention to different types of feedback, as well as exploring and incorporating context and defining universal taxonomies. By creating an initial generalisation of exiting game elements and adapting them to educational contexts, we can infer that instructors and future research may find easier to analyse existing systems and extract the gamification elements within it. Based on the exposed elements, this section will discuss the implications of using each in an educational environment.

Measurement dimension

This Dimension, as shown in the examples, must always be present so the user may have feedback on their actions. Concerning the game elements in this Dimension, the lack of **Acknowledgement** may lead the user to a state of frustration, since their interactions are not being recognised as something important, whereas providing acknowledgements not properly planned may cause unexpected outcomes (e.g., earning badges based on time to finish a task may lead the students to complete tasks as fast as possible without taking into account whether they are correct). As for **Level**, it is considered a relevant element, especially when tied to **Progression**, according to (Toda et al. 2019a). Lack of levels may lead the learner to think that they did not advance at all in their skills. Following, according to (Toda et al. 2019a), Progression is also considered a highly relevant element to learners, independent of gender. Lack of progression might lead the learner to a feeling of frustration and anxiety (Dignan 2011). Finally, **Stats** is also presented in almost all educational environments, the lack of information makes the learner feel disoriented (Dignan 2011). Although, the literature on this topic still hasn't reached a consensus on the best way to relate or use these elements properly.

Ecological dimension

Concerning this Dimension, it is related to concepts that act as properties of the environment that can be implemented in a subtle way to engage the users to follow the desired behaviour. They can be supported by the elements in the Measurement/Feedback Dimension, to ensure the behaviour is followed. Although, most of these elements must be designed with care since they can affect the learners' interactions drastically. **Chance** is directly affected by the users' luck; some strategies can be used to mitigate the "bad luck" effect as including an automatic success after a certain number of tries. When the **Economy** is not related to the content, the user may lose focus on what is important (Snow et al. 2015). Although, the users might find attractive when the Economy is tied directly to advantages related to the class, e.g. using their coins to postpone a test (Toda et al. 2016). Lack of **Imposed Choice** within the system might lead the learner to a state where they feel their actions are not meaningful (Dignan 2011), at the same time excessive freedom may allow the students to perform undesired actions. As for **Rarity**, the addition of limited events that rewards exclusive badges or another kind of feedback may engage the learners, but the presence of rare resources and their constraints might demotivate the learners. Lack of rarity may lead the learner to boredom (Dignan 2011) Finally, the absence of **Time Pressure** may lead the learner to a state of boredom since they might not feel challenged or pressured to complete a task (Dignan 2011). An example of using time pressure more healthily is to provide flexible

deadlines, where the learner is responsible for the completion of the task. Time pressure is implicit in Massive Online Open Courses (MOOC) systems, which may be one of the reasons why the dropout rates are high (Cristea et al. 2018).

Social dimension

This Dimension is concerned with the Social aspects of the environment. The elements that connect people and influence their behaviour towards a task. Since this Dimension is concerned with interactions between the learners (instead of interactions with the system) it must be designed carefully. On one hand, **Competition** can create a healthy environment where the learners try to overcome their peers to achieve a certain prize, on the other hand, it has a huge potential to demotivate the learner when their performance is not as expected. An example on how to design a good competition is trying not to tie it to any content-based activity, or by creating groups to mitigate any kind of isolation effect[4] (Papadopoulos et al. 2016; Toda et al. 2018a). **Cooperation** is seen as a positive addition in most educational environments, although its implementation may be complex. The absence of Cooperation may lead to isolation, which may increase the odds of demotivation or disengagement of the learner, whereas using it may lead the students to share knowledge and to work harder in order to avoid jeopardising their peers. One of the major examples of success in Cooperation is Wikipedia. **Reputation** is related to the social status the learners may acquire in the environment, e.g. Best Student in the course. Lack of reputation is similar to the lack of acknowledgment and point, where the learner may feel their actions are not meaningful (Dignan 2011), but also must be designed with care or learners might feel demotivated due to not acquiring a certain status. Finally, **Social Pressure** is usually considered as one of the most irrelevant amongst all elements (Toda et al. 2019a) but can be helpful if properly designed, e.g. persuading a high score learner to encourage a disengaged peer that has a poor performance. Assigning peer-review activities might also imply social pressure.

Personal dimension

This dimension is directly related to the learner using the environment. It presents elements that are intrinsic to educational environments and the learner might not perceive these elements as gamification. According to our analysis, all educational environments contained the five elements of this dimension, however, some of them (e.g. MeuTutor) did not use these elements in a way that could favour the learner (e.g. the Renovation element is present, but the student does not gain more points by redoing a task). Concerning each element, **Objective** is presented in all educational environments, since the main focus of these applications is to make the student learn or practice a concept, whilst being cautious not to encourage undesired behaviours (e.g., an objective of completing many tasks may lead students to complete numerous of those without properly seeking to correctly complete them). Lack of objectives may misguide or confuse the learner. According to Toda et al. (2019a), it is the most relevant element to use within gamified educational environments. Besides, as repetition or static environments[5] may jeopardise the learning process, **Novelty** may aid in this

[4]Where a student feels they are not good enough and stop doing the activities
[5]Environments that do not receive updates

perspective as well (Mustafa et al. 2019). However, adding Novelty can be complex as it often requires human effort or automatic generation techniques (Shehadeh et al. 2017). As for the **Puzzle**, it is represented through challenges and cognitive tasks, which are common to any educational environment. Lack of Puzzle can make the environment look dull and demotivate the user (e.g. an environment where the learner can only watch videos without any kind of interaction or tasks related to it may lead these learners to boredom.). **Renovation** is also a concept that is present in almost all educational environments since learners can redo a task if they fail, or just want to remember a concept (e.g. rewatching a video or redoing a task). Although, Renovation is not always presented as a gamification element since the user does not benefit from using it (e.g. gaining points by rewatching a video). Lack of Renovation usually make learning environments to feel more difficult which can demotivate the students. In most nonvirtual educational environments, the lack of Renovation is what makes the educational process tedious to learners (Smith-Robbins 2011). Finally, **Sensation** is usually presented as a pleasant interface that is appealing to the user. Although some educational environments are investing in the use of Augmented Reality (AR) and Virtual Reality (VR) with gamification features, it is still a new emergent area. According to Toda et al. (2019a), Sensation is considered a highly relevant element.

Fiction dimension

Considering this Dimension, it is not common or considered when designing gamified educational environments (Palomino et al. 2019). This occurs since most gamification frameworks do not make a differentiation between Narrative different layers and Storytelling. The **Narrative** is related to the learner's interaction with the system, affected by their characteristics. If designed correctly, it can help the learner to focus on the content rather than the game elements around it. **Storytelling** is a way to materialise the Narrative, using techniques with the aid of text, audio-visual and another sensorial stimulus, stabilising how the story (or context) is told. The absence of Narrative may hinder the students' engagement and focus on the content to be learned. As for the lack of Storytelling, it might lead to context confusion, causing the student to not see a reason to perform a certain task from the gamification point of view. Storytelling can be used to give a context (e.g. a theme) to the environment, e.g. telling the learner they are fighting a boss that takes damage for each correct task.

Conclusions and future works

This work presented how we could use an existing taxonomy to analyse and evaluate gamified systems. We improved the description of the game elements as well as provide examples on how to use each to analyse educational systems. We also proposed an initial hierarchy to classify those elements into Five Dimensions, which can provide support to designers and developers of educational environments. Finally, we proposed a link between this hierarchy and aspects such as feedback, user interaction, and motivation.

Through our discussions, we debate some advantages and disadvantages of using each Dimension. Some limitations of the current work are that we did not evaluate the acceptance of the new grouped dimensions with experts, but with five

researchers only due to time constraints. Finally, as future work, we intend to explore the learners' perception of this taxonomy to identify the best practices on how to use the elements properly (by using data-driven approaches and/or machine learning algorithms). Through this future exploration, we believe we may find concrete guidelines on how to gamify educational environments and give those guidelines to teachers, instructors, designers and/or developers.

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Authors' contributions
The taxonomy was proposed by AMT, ACTK, WO, LR, PTP and AIC. The visual representation was designed by PTP. The study design was proposed by AMT, ACTK, IG and AIC. AIC, SI, IB, LS and IG supervised the activities and wrote parts of and reviewed the paper for final submission. All authors read and approved the final manuscript.

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Availability of data and materials
All the materials and data are available within the paper.

Competing interests
The author(s) declare(s) that they have no competing interests.

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References

Azouz, O., & Lefdaoui, Y. (2018). Gamification design frameworks: A systematic mapping study. In *International Conference on Multimedia Computing and Systems -Proceedings* (Vol. 2018-May, pp. 1–9). IEEE. https://doi.org/10.1109/ICMCS.2018.8525900.

Barata, G., Gama, S., Jorge, J., & Gonçalves, D. (2015). Gamification for smarter learning: Tales from the trenches. *Smart Learning Environments, 2*(1), 10. https://doi.org/10.1186/s40561-015-0017-8.

Cristea, A. I., Alamri, A., Kayama, M., Stewart, C., Alshehri, M., & Shi, L. (2018). Earliest predictor of dropout in MOOCs: A longitudinal study of FutureLearn courses. In *27TH International Conference On Information Systems Development (ISD2018)*. Sweden: Lund. Retrieved from www.futurelearn.com.

Deterding, S., Sicart, M., Nacke, L., O'Hara, K., & Dixon, D. (2011). From Game Design Elements to Gamefulness: Defining "Gamification." *Proceedings of the 2011 Annual Conference Extended Abstracts on Human Factors in Computing Systems - CHI EA '11*, 2425. https://doi.org/10.1145/1979742.1979575

Dichev, C., & Dicheva, D. (2017, December 20). Gamifying education: What is known, what is believed and what remains uncertain: A critical review. *International Journal of Educational Technology in Higher Education* Nature Publishing Group. https://doi.org/10.1186/s41239-017-0042-5.

Dignan, A. (2011). *Game Frame. Using games as a strategy for success*. Free Press.

Hanus, M. D., & Fox, J. (2014). Assessing the effects of gamification in the classroom: A longitudinal study on intrinsic motivation, social comparison, satisfaction, effort, and academic performance. *Computers & Education, 80*, 152–161. https://doi.org/10.1016/j.compedu.2014.08.019.

Hunicke, R., LeBlanc, M., & Zubek, R. (2004). MDA: A formal approach to game design and game research. *Workshop on Challenges in Game AI*, 1–4. https://doi.org/10.1.1.79.4561

Huynh, D., Zuo, L., & Iida, H. (2016). Analyzing gamification of "Duolingo" with focus on its course structure. In *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* (Vol. 10056 LNCS, pp. 268–277). Cham: Springer, https://doi.org/10.1007/978-3-319-50182-6_24.

Kapp, K. M. (2012). The Gamification of Learning and Instruction: Game-based Methods and Strategies for Training and Education. Retrieved from http://dl.acm.org/citation.cfm?id=2378737

Klock, A. C. T., De Borba, E. J., Gasparini, I., Lichtnow, D., Pimenta, M. S., & Rodriguez, G. (2017). Evaluation of usability and user experience regarding the Gamification of educational systems. In *12th Latin American Conference on Learning Objects and Technologies, LACLO 2017* (Vol. 2017, pp. 1–8). IEEE. https://doi.org/10.1109/LACLO.2017.8120907.

Klock, A. C. T., Gasparini, I., & Pimenta, M. S. (2016). 5W2H Framework. In *Proceedings of the 15th Brazilian symposium on human factors in computer systems - IHC '16* (pp. 1–10). New York: ACM Press. https://doi.org/10.1145/3033701.3033715

Klock, A. C. T., Ogawa, A. N., Gasparini, I., & Pimenta, M. S. (2018a). Does gamification matter? A systematic mapping about the evaluation of gamification in educational environments. In *Proceedings of the 33rd Annual ACM Symposium on Applied Computing* (pp. 2006–2012). New York: ACM Press. https://doi.org/10.1145/3167132.3167347.

Klock, A. C. T., Ogawa, A. N., Gasparini, I., & Pimenta, M. S. (2018b). Integration of learning analytics techniques and gamification: An experimental study. In *Proceedings - IEEE 18th International Conference on Advanced Learning Technologies, ICALT 2018* (pp. 133–137). IEEE. https://doi.org/10.1109/ICALT.2018.00039.

Koivisto, J., & Hamari, J. (2019, April 1). The rise of motivational information systems: A review of gamification research. *International Journal of Information Management. Pergamon.* https://doi.org/10.1016/j.ijinfomgt.2018.10.013.

Lee, J. J., & Hammer, J. (2011). Gamification in education: What, how, why bother? *Academic Exchange Quarterly, 15*, 1–5 Retrieved from http://dialnet.unirioja.es/servlet/articulo?codigo=3714308.

Marczewski, A. (2015). Even ninja monkeys like to play: Gamification, game thinking and motivational design. In *Gamified UK* (pp. 65–80). Gamified UK.

Martí-Parreño, J., Seguí-Mas, D., & Seguí-Mas, E. (2016). Teachers' attitude towards and actual use of Gamification. *Procedia - Social and Behavioral Sciences, 228*, 682–688. https://doi.org/10.1016/j.sbspro.2016.07.104.

Mora, A., Riera, D., Gonzalez, C., & Arnedo-Moreno, J. (2015). A literature review of Gamification design frameworks. In *2015 7th International Conference on Games and Virtual Worlds for Serious Applications (VS-Games)* (pp. 1–8). IEEE. https://doi.org/10.1109/VS-GAMES.2015.7295760.

Mora, A., Riera, D., González, C., & Arnedo-Moreno, J. (2017). Gamification: A systematic review of design frameworks. *Journal of Computing in Higher Education*. https://doi.org/10.1007/s12528-017-9150-4.

Mustafa, G., Abbas, M. A., Hafeez, Y., Khan, S., & Hwang, G. J. (2019). Effectiveness of ontology-based learning content generation for preschool cognitive skills learning. *Interactive Learning Environments, 27*(4), 443–457. https://doi.org/10.1080/10494820.2018.1484772.

Nand, K., Baghaei, N., Casey, J., Barmada, B., Mehdipour, F., & Liang, H.-N. (2019). Engaging children with educational content via Gamification. *Smart Learning Environments, 6*(1), 6. https://doi.org/10.1186/s40561-019-0085-2.

Palomino, P. T., Toda, A. M., dos Santos, W. O., Cristea, A. I., & Isotani, S. (2019). Narrative for gamification in education: Why should you care? In *Proceedings of the 19th IEEE International Conference on Advanced Learning Technologies*.

Papadopoulos, P. M., Lagkas, T., & Demetriadis, S. N. (2016). How revealing rankings affects student attitude and performance in a peer review learning environment. In *Communications in Computer and Information Science* (Vol. 583, pp. 225–240). Springer International Publishing. https://doi.org/10.1007/978-3-319-29585-5_13.

Pedreira, O., García, F., Brisaboa, N., & Piattini, M. (2015). Gamification in software engineering - A systematic mapping. *Inf. Softw. Technol., 57*(1), 157–168. https://doi.org/10.1016/j.infsof.2014.08.007.

Sánchez-Mena, A., & Martí-Parreño, J. (2016). Gamification in higher education: Teachers' drivers and barriers. *Proceedings of the International Conference of The Future of Education*, (July).

Seaborn, K., & Fels, D. I. (2014). Gamification in theory and action: A survey. *Internatoinal Journal of Human-Computer Studies, 74*, 14–31. https://doi.org/10.1016/j.ijhcs.2014.09.006.

Shehadeh, A., Felfernig, A., Stettinger, M., Jeran, M., & Reiterer, S. (2017). Automated learning content generation from knowledge bases in the STUDYBATTLES environment. In *International Journal of Software Engineering and Knowledge Engineering* (Vol. 27, pp. 1387–1408). https://doi.org/10.1142/S0218194017400022.

Shi, L., Cristea, A. I., Hadzidedic, S., & Dervishalidovic, N. (2014). Contextual Gamification of social interaction – Towards increasing motivation in social E-learning. In *ICWL 2014* (Vol. 8613, pp. 116–122). Retrieved from https://pdfs.semanticscholar.org/a53e/464fb4bc6326c217d77b38496169f7b52686.pdf

Smith-Robbins, S. (2011). This game sucks: How to improve the Gamification of education. *Educ. Rev., 46*(1), 58–59. https://doi.org/10.1109/IEMBS.2005.1616259.

Snow, E. L., Allen, L. K., Jackson, G. T., & McNamara, D. S. (2015). Spendency: Students' propensity to use system currency. *International Journal of Artificial Intelligence in Education, 25*(3), 407–427. https://doi.org/10.1007/s40593-015-0044-1.

Toda, A., Silva, Y., Cruz, W., Xavier, L., Isotani, S., Rafael, Y., … Isotani, S. (2016). Um processo de Gamificação para o ensino superior: Experiências em um módulo de Bioquímica. In *Anais do Workshop de Informática na Escola* (Vol. 22, p. 495). https://doi.org/10.5753/cbie.wie.2016.495.

Toda, A. M., do Carmo, R. M. C., da Silva, A. P., Bittencourt, I. I., & Isotani, S. (2018a). An approach for planning and deploying gamification concepts with social networks within educational contexts. *International Journal of Information Management*. https://doi.org/10.1016/J.IJINFOMGT.2018.10.001.

Toda, A. M., Oliveira, W., Klock, A. C., Palomino, P. T., Pimenta, M., Gasparini, I., … Cristea, A. I. (2019a). A taxonomy of game elements for Gamification in educational contexts : Proposal and evaluation. 19th international conference on advanced learning technologies - in press, 1–5. https://doi.org/10.1109/ICALT.2019.00028.

Toda, A. M., Oliveira, W., Shi, L., Bittencourt, I., Isotani, S., & Cristea, A. (2019b). Planning Gamification strategies based on user characteristics and DM : A gender-based case study. In *Proceedings of the Educational Data Mining 2019 conference* (pp. 438–443). Montréal. Retrieved from http://arxiv.org/abs/1905.09146

Toda, A. M., Valle, P. H. D. D., & Isotani, S. (2018b). The dark side of Gamification: An overview of negative effects of Gamification in education. In *Communications in Computer and Information Science* (Vol. 832, pp. 143–156). Springer, Cham. https://doi.org/10.1007/978-3-319-97934-2_9.

Werbach, K., & Hunter, D. (2012). *For the win: How game thinking can revolutionize your business*. Wharton Digital Press. Retrieved from https://books.google.com/books?id=abg0SnK3XdMC&pgis=1

Publisher's Note

ANNEX

J

HOW TO GAMIFY LEARNING SYSTEMS? AN EXPERIENCE REPORT USING THE DESIGN SPRINT METHOD AND A TAXONOMY FOR GAMIFICATION ELEMENTS IN EDUCATION

How to Gamify learning Systems? An Experience Report using the Design Sprint Method and a Taxonomy for Gamification Elements in Education

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ABSTRACT: One of the main goals of gamification in educational settings is to increase student motivation and engagement. To facilitate the design of gamified educational systems, in recent years, studies have proposed various approaches (e.g., methodologies, frameworks and models). One of the main problems, however, is that most of these approaches are theoretical, and do not provide a *proof-of-concept*. This paper advances the state of the art by providing a practical way to help implement this kind of system. In this study, we present, for the first time, how one can apply gamification elements in a learning system using the *Design Sprint* method, to guide designers and developers on replicating this process. Additionally, as starting point, we use a taxonomy composed of 21 game elements, proposed to be used within learning environments, organised into five game element categories, according to their goal/usage. Our main contribution is to present *how to systematically implement the gamification elements focused on educational ends*, which is of special value to practitioners, designers and developers.

Keywords: Gamification, Design Sprint, Taxonomy, Design, Education

1. Introduction

Gamified systems adoption has increased in the last decade, since the definition was coined (Thiebes, Lins, & Basten, 2014). These systems aim at using game-like elements to provide a gameful experience to their users (Landers, 2019; Thiebes et al., 2014). This caught the attention of education professionals, since the field of education still struggles with motivating and engaging students (Borges, et al., 2014; Lee & Hammer, 2011; Martí-Parreño, Seguí-Mas, & Seguí-Mas, 2016; Paula & Fávero, 2016; Sánchez-Mena & Martí-Parreño, 2016; Toda et al., 2018a). In education, gamification consists of using game-like elements to achieve positive impacts in motivating, engaging, persuading and improving the performance of students (Deterding, Sicart, Nacke, O'Hara, & Dixon, 2011; Kapp, 2012; Seaborn & Fels, 2014). According to recent research, gamified systems impact on psychological characteristics, and effective gamified systems lead to behavioural change (Landers, 2019). However, for a positive impact, gamification needs to follow a *well-thought design process*; otherwise, it may lead to undesired behaviours, or worsen performance, due to disengagement or other declining effects (De-Marcos, Domínguez, Saenz-de-Navarrete, & Pagés, 2014; Dichev & Dicheva, 2017; Toda et al., 2018b; Zichermann & Cunningham, 2011). Therefore, many authors proposed the use of frameworks and methodologies to support the gamification design process (Mora, Riera, González, & Arnedo-Moreno, 2017).

However, these gamification frameworks and methods present some limitations, ranging from their purpose, to the number of definitions of game elements used, which can confuse and drive away designers, developers, teachers, and instructors who wish to gamify their learning activities (Koivisto & Hamari, 2019; Pedreira, García, Brisaboa, & Piattini, 2015). Moreover, some frameworks are too generic and do not encompass learning objectives and other properties derived from the education field, and others are too specific to a given niche (Mora et al., 2017); e.g., the framework proposed by Kotini and Tzelepi (2015), focused on gamifying computational thinking activities. As for the definitions, literature sees it as a considerable limitation on the field of gamification, since there are many gamification frameworks (more than 40, up to date) and all of them use different types of game elements that may not encompass all elements within a game. Additionally, recent studies report the lack of proof-of-concept in gamification studies that may support the theories on which they are based (Kasurinen & Knutas, 2018).

To address this, this work presents and applies a recent taxonomy, created and evaluated to mitigate the issues related to the game elements definitions (Toda et al., 2019a) and the lack of proof-of-concept for gamification frameworks. The taxonomy is composed of 21 game elements to be used within learning environments, which were grouped into five game element categories, according to their goal/usage (Toda et al., 2019b). Next, we present how we can apply that taxonomy using the Design Sprint Method (Sumual, Batmetan, & Kambey, 2019), to guide designers and developers on replicating this process. Hence, we propose the following research question: *How can we gamify learning environments using the Design Sprint method and existing game elements?* Thus, our main contribution is presenting how to systematically implement a recent, expert-validated gamification elements taxonomy, that is focused on educational ends, which is of special value to practitioners (e.g., designers, developers, teachers, and professors), who aim to use this taxonomy to implement gamification in their learning environments.

The rest of the paper is organised as follows: the next section introduces the research background, by reviewing relevant gamification frameworks in education. The research model used in this research is then described, followed by the description of the application of the taxonomy. Finally, the implications of the findings are discussed, and conclusions are drawn.

1.1 Background and related works

Gamification in education is not a novelty, as many studies have focused on applying game elements in learning environments, even before the concept was coined (Darejeh & Salim, 2016; Dichev & Dicheva, 2017; Vargas-Enriquez, Garcia-Mundo, Genero, & Piattini, 2015). The purpose of using gamification in education is to motivate and engage students, to improve their performance and training, and change undesired behaviours (Huotari & Hamari, 2012; Kapp, 2012; Seaborn & Fels, 2014). However, the literature in this field reported mixed results on the application of gamification, wherein most of the negative impacts were related to a poor design (Dichev & Dicheva, 2017; Toda et al., 2018b).

The factors that influence a poor design ranged from users' demographic to behavioural profiles, context and learning activities, and the way the gamified strategies were designed, or recommended (Klock, Gasparini, & Pimenta, 2016; Toda et al., 2019c). Considering the latter, most of the existing frameworks were either conceptual or lacked proper definitions of game elements. Moreover, recent conceptual frameworks lacked empirical evidence on their use, which hindered their adoption by teachers and instructors (Pedreira et al., 2015; Sánchez-Mena & Martí-Parreño, 2016). Furthermore, the lack of proper definitions may confuse designers and other education domain specialists, since most frameworks used not only different names for the same concept, but also the same definition for different concepts; e.g., in Gamify-SN (Toda et al., 2018a) the authors define "acknowledgements" as a type of feedback given to the users when certain actions are performed, while in another framework (Wongso, Rosmansyah, & Bandung, 2014) the authors define the same element as "medals" or "badges."

Furthermore, considering frameworks in the field of education, a recent systematic review (Mora et al., 2017) found 6 frameworks. From this group, one is focused on serious games and five others on gamification.

Simões, Redondo and Vilas (2013) presented a framework for educational platforms divided into three groups. The first group described game elements (N = 12) divided into game mechanics and dynamics. Following, the second group presented guidelines for teachers, focusing on learning tasks, however, without linking these tasks to the game elements. A third group connected focused these guidelines, aligning the objectives with the school identity. These objectives aimed to help students overcome failure, achieve the flow state (Csikszentmihalyi, 1975), experience new roles and enhance their skills. However, the framework did not present empirical evidence concerning its application to learning environments.

Following, Wongso et al. (2014) proposed a framework for educational domains focused on linking gamification and Web 2.0 social features with five steps: Analysis, Design, Development, Implementation and Evaluation. Game elements and social features are defined in the Analysis step. The authors considered game elements as game mechanics (N = 7), further linked to tasks developed in the Design phase. Nonetheless, the authors did not present an empirical validation.

Kotini and Tzelepi (2015) designed a gamification framework focused on gamifying computational thinking courses. The framework divided the game elements (N = 18) into three categories: Behaviour, Progression and Feedback. These groups were tied to computational thinking skills, behaviours and definitions. Nonetheless, the framework did also lack an empirical validation (e.g., any instance or proof-of-concept on its usage) and the elements were heavily tied to the concepts of computational thinking, which may have hindered adoption by other fields.

Concerned with software development, Mora, Zaharias, González, and Arnedo-Moreno (2016) also proposed a framework for education, called FRAGGLE. This framework used an Agile method from software engineering and gamification features, aligned with learning objectives, to gamify learning systems. The framework was focused on aiding developers and designers and consisted of 4 main steps: Declaration, Creation, Execution and Learning. They considered the use of player profiles to select game mechanics. Again, no empirical evidence was provided, nor a description on the game elements that can be used.

Finally, the most recent framework for gamified education was designed by Ana et al. (2016) where they developed a user-centred gamification framework for the educational field. This framework was organised into 7 steps: Who? What? Why? When? How? Where? How Much? The framework was applied and evaluated with 139 students enrolled in an online course, providing empirical evidence on its use and efficiency on motivation, performance and engagement. This is the only framework to have empirical evidence on its use. However, the framework presented little on the use of game elements and it was focused on learning systems, while ours can be used with unplugged gamification (i.e., the use of gamification without a computer or digital tool).

Considering the related works, we can observe that none of them presented any kind of validation to the game elements that were used nor provided usage information of these elements, e.g., how these elements can be applied within the context of the framework. Only one work presented empirical evidence on its use and another provided partial evidence (e.g., presented how the system worked). As for the definitions and number of elements included, most of the frameworks focused only on elements that acted as a kind of feedback (e.g., points, levels and badges) not considering contextualising elements, such as Narrative and Storytelling. To the best of our knowledge, our study is the first study to use a validated set of game elements to gamify learning systems. Table 1 presents a comparison between ours and related works. Some of the studies appear as having provided partial empirical evidences, meaning lack of methods to measure what was intended or focused upon. Also, none of the frameworks presented an explicit way on how to use the game elements.

Table 1. Related works comparison

Work	# of Game Elements	Provides empirical evidence?	Provides validation of the game elements?	Provides a how-to-use the game elements?
Simões et al (2012)	12	Partially, used in a digital learning environment.	No	No, presented the system with the game elements.
Wongso et al (2014)	7	No	No	No
Kotini and Tzelepi (2015)	18	No	No	No
Mora et al (2015)	Not explicit	No	No	No
Klock et al (2019)	17	Yes, used in a learning environment.	No	No, presented the system with the game elements.
Our study	21	Yes	Yes, a validation based on experts' opinion.	Yes

2. Research method

Our study uses the Design Sprint method, developed by GV (Google Ventures). Its focus is to answer critical business questions through design, prototyping and testing ideas (as a proof-of-concept, i.e., the practical model that can prove the theoretical concept established by research). It has been used to design new products, develop new

features, and define marketing strategies, with a good cost-benefit rating. Comparing it with other agile methods, such as Scrum's sprints, the Design Sprint is focused on learning about an idea, without having to build and launch it, as shown in Figure 1. As such, one of the main advantages of this method is the possibility to shortcut debate cycles and compress months of time into a single week (Sumual et al., 2019).

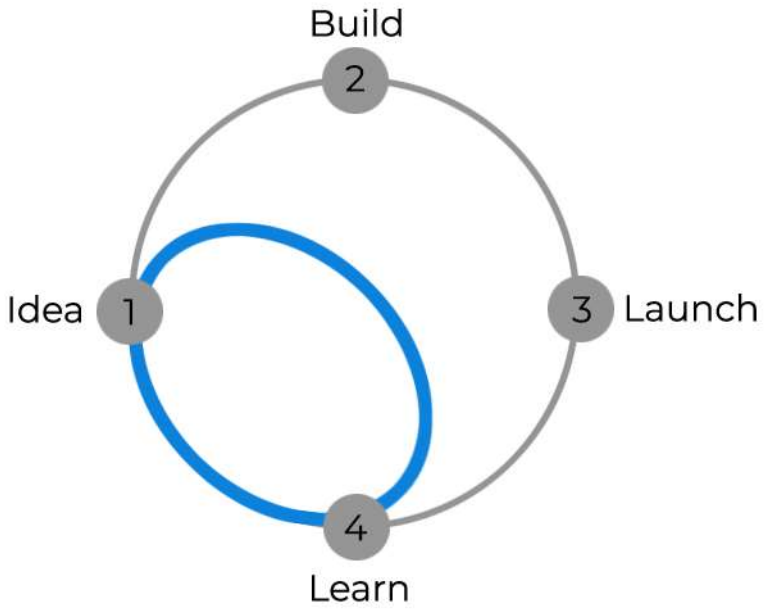

Figure 1. Design Sprint shortcut to learning, without building and launching (Knapp et al. 2019)

In gamification context, as stated in the previous sections of this paper, one of the main problems of its effectiveness is the lack of guidelines and coherent methods to create the strategies and/or applications. Therefore, we chose to work with a systematic and established method for creating and validating new ideas and products, in their conceptual stages, to evaluate the empirical application of the gamification taxonomy for educational purposes and allowing for the proof-of-concept for future building and launching of a digital product based on it. The first step to use the Design Sprint is to set the stage, establishing the right challenge and the right team to deal with it. After that, the sprint is split into five steps (ideally one for each weekday).

1. **Understanding and discussions:** The first day of structured discussions should organise the subsequent steps for the rest of the week. Amongst the tasks included are: establishing a long-term goal and mapping the challenge, picking a target to work (Knapp et al., 2019);
2. **Focus on solutions:** On the second day of the sprint, brainstorming is performed, reviewing existing ideas, in order to remix and improve them. Then, we progress to the sketch phase, emphasising critical thinking (Knapp et al., 2019);
3. **Decision:** here, the team chooses one solution to work, test, and validate, creating a step-by-step plan for the prototype (Knapp et al., 2019);
4. **Prototype:** In the fourth day/step, the team creates the prototype, focusing on testing with customers (end-users). Here, all planning is reviewed and organised for the final step of the sprint (Knapp et al., 2019);
5. **Test and validate:** This includes testing the prototype, interviewing customers and/or learning by watching them reacting to the prototype. As a result, the team knows whether an idea is feasible or not, ending the sprint (Knapp et al., 2019).

For our research, we used the Design Sprint method to validate the use of our taxonomy in the creation, prototyping and testing of an educational gamified application. At this stage of the research, we were not concerned with the application interface and, therefore, the user prototype. Instead, our focus was on the design of gamification strategies (i.e., how can the 21 game elements be used to improve learning experience in a gamified educational system).

The taxonomy used (Toda et al., 2019a) is composed of 21 gamification elements for the education field (Figure 2). These game elements were collected from the literature and focused on creating a syllabus for gamification in education. The authors defined a concept, alongside its synonyms, and a definition for each of the 21 elements. This taxonomy was validated by 19 experts on the field of gamification and education (most of the experts were also lecturers and professors), achieving an overall acceptance of its elements, concepts and definitions. Thus, in summary, we chose this approach as it is an expert-validated, state-of-the-art alternative, specifically developed for educational environments that suits our need.

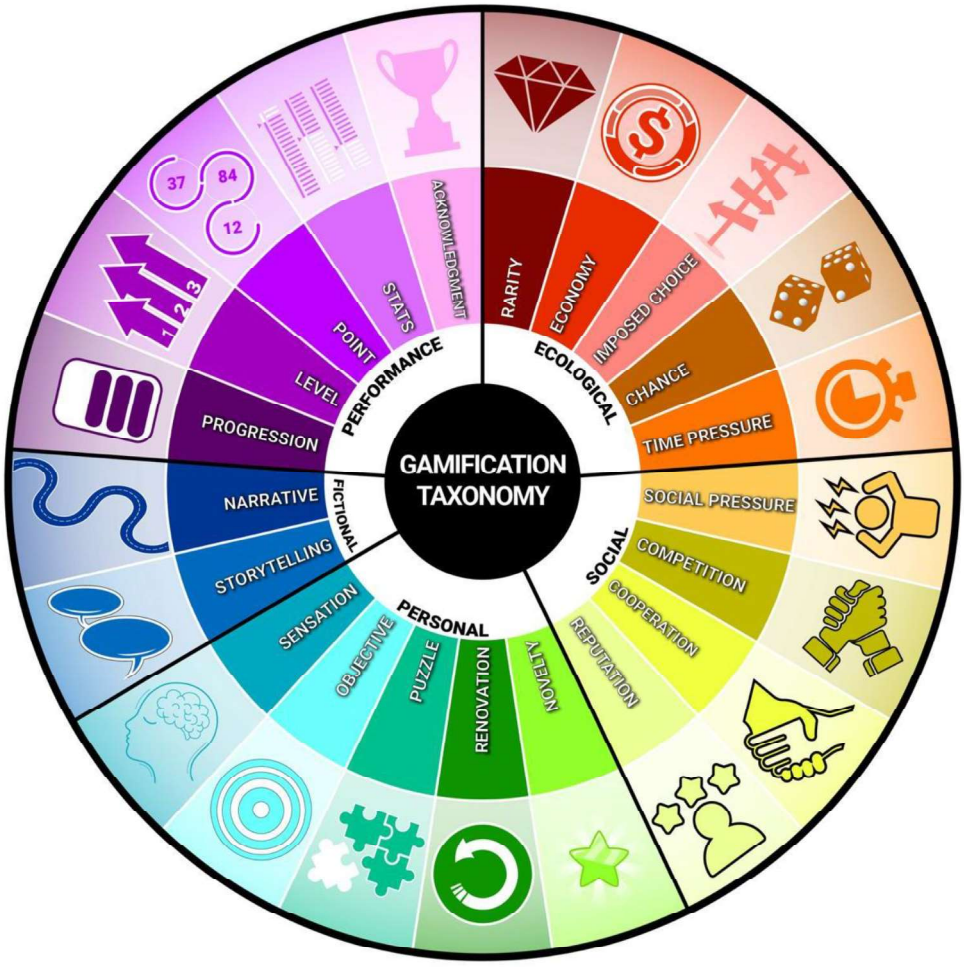

Figure 2. Taxonomy design (Toda et al., 2019b)

According to Toda et al. (2019b), those elements have been hierarchically linked by classification into five dimensions, related to *performance/measurement*, *environment*, *social/personal interaction* and *student experience*. Importantly, all the 21 elements contain synonyms of alternate names found in the literature (Table 2), for domain specialists to be able to use this taxonomy's recommendations alongside other frameworks. In the next section, we describe how this method was used in our context and the results arising from it.

Table 2. Gamification elements and definitions (Toda et al., 2019a)

Concept	Description	Dimension
Acknowledgement	Type of feedback that praises the players' specific actions. Some examples and synonyms are badges, medals, trophies.	Performance
Chance	Randomness and probability properties that increase or decrease the odds of certain events; examples/synonyms: randomness, luck, fortune.	Ecological
Competition	When two or more players compete against each other towards a common	Social

	goal; examples/synonyms: Player vs Player, scoreboards, conflict.	
Cooperation	When two or more players collaborate to achieve a common goal; examples/synonyms: teamwork, co-op missions.	Social
Economy	Transactions within the game, monetising game values and other elements; examples/synonyms: markets, transaction, exchange.	Ecological
Imposed Choice	Decisions that the player is obliged to make in order to advance the game; examples/synonyms: judgements, forced choices (different from Narrative).	Ecological
Level	Hierarchical game layers, providing a gradual way for players to obtain new advantages upon advancing; examples/synonyms: character levels, skill level.	Performance
Narrative	Order of events happening in a game; i.e., choices influenced by player actions; examples/synonyms: strategies the player uses to go through a level (stealth or action), also the good/bad actions influencing the ending, karma system (different from Imposed Choice).	Fiction
Novelty	New, updated information presented to the player continuously; examples/synonyms: changes, surprises, updates.	Personal
Objectives	Guide the players' actions. Quantifiable or spatial, from short- to long-term; examples/synonyms are missions, quests, milestones.	Personal
Point	Unit used to measure users' performance; examples/synonyms: scores, number of kills, experience points.	Performance
Progression	This allows players to locate themselves (and their progress) within a game; examples/synonyms: progress bars, maps, steps.	Performance
Puzzles	Challenges within the game that should make a player think examples/synonyms: actual puzzles, cognitive tasks, mysteries.	Personal
Rarity	Limited resources and collectables; examples/synonyms: limited items, rarity, collection.	Ecological
Renovation	When players can redo/restart an action; examples/synonyms are extra life, boosts, renewal.	Personal
Reputation	Player titles to accumulate in-game; examples/synonyms: titles, status, classification.	Social
Sensation	Use of players' senses to create new experiences; examples/synonyms: visual stimulation, sound stimulation.	Personal
Social Pressure	Pressure through social interactions with another player (s) (playable and non-playable); examples/synonyms: peer pressure, guilds.	Social
Stats	Visible information for the player, about their in-game outcomes; examples/synonyms: results, health bar, magic bar, HUD, indicators, data from the game presented to the user.	Personal
Storytelling	The way the story of the game is told (as a script) within the game, via text, voice, or sensorial resources; examples/synonyms: stories told through animated scenes, audio queues or in-game text queues.	Fiction
Time Pressure	Pressure through time in-game; examples/synonyms: countdowns, clock, timer.	Ecological

3. Application

In this section, we aim to describe how we used the Design Sprint method to propose the gamification design instantiating the taxonomy proposed by Toda et al., (2019a). Our main idea was to use the Design Sprint method in order to think, propose, prototype and evaluate the gamification design. The team is composed of five experts (each with more than five years of experience) in Education, Computer Science, Gamification Design, and Human-computer Interaction (HCI). This number is also a recommendation by Nielsen and Landauer (1993).

On the **First Day** (understanding and discussions), the team members set the long-term goal, mapped project challenges, and set targets for the project execution. As a result, it was decided to propose a gamification design, capable of being used in the implementation of different gamified systems and implementing the gamification

elements proposed in the taxonomy. In the challenge mapping stage, four challenges were defined to guide the project management:

1. **Definition of a general gamification design architecture (Day 1 and 2)**: At this stage, the main objective was to define a general architecture of a gamified educational system and defining how the elements could be organised (i.e., on which pages each element should appear); this was done through a brainstorming session.
2. **Implementation of the elements according to the taxonomy (Day 3)**: At this state, the main objective was to define how gamification elements should be organised and the internal relationships between elements and activities in the system (e.g., when finishing an activity, which gamification elements should be changed as a reward to the user); to achieve this step, we mapped the activities and events on the system and matched each with the elements based on recommendations presented in previous works (Toda et al., 2018a; Toda et al., 2019c).
3. **Gamification design proposal (Day 3 and 4)**: At this stage, the main objective was to write the documentation of the gamification design, condensing the results from the previous steps. In other words, this meant formalising the gamified strategies (A gamified strategy in the scope of this work is an event that links a task and a given gamification element, e.g., Perform a Login (Task) and receive a badge (Gamification element: Acknowledgement)).
4. **Gamification design instantiation (Day 5)**: In this step, the main objective was to apply the design in a learning system.

On the **Second Day** (focus on solutions), team members reviewed what was defined in the previous day. Through meetings and brainstorming sessions, the team re-analysed what was proposed and made any changes that could impact onto the final system. Then, an outline of the proposal was defined, seeking to relate each gamification element and discussing how the elements could be implemented. These annotations and definitions were made using Trello (see https://www.trello.com), a system design to manage team projects.

On the **Third Day** (decision), team members detailed how each gamification element should be implemented in educational systems, and how these elements relate to each other. At the end of the day, the team finished the gamification design, seeking to define how the elements proposed in the taxonomy could be grouped, organised and implemented within an educational system, through the gamified strategies (Figure 3). An example was to design the Home page. In this page, the students would have visual access to certain elements, as the weekly leaderboard (Competition and Time Pressure), Cooperation (Their groups), their progress within the system (Point, Level, Progression, Acknowledgement and Reputation) as well as the missions that were assigned to them (Objectives). These elements were combined and proposed based on the recommendations of the Taxonomy and other studies that validated those combinations with students (Toda et al., 2019d).

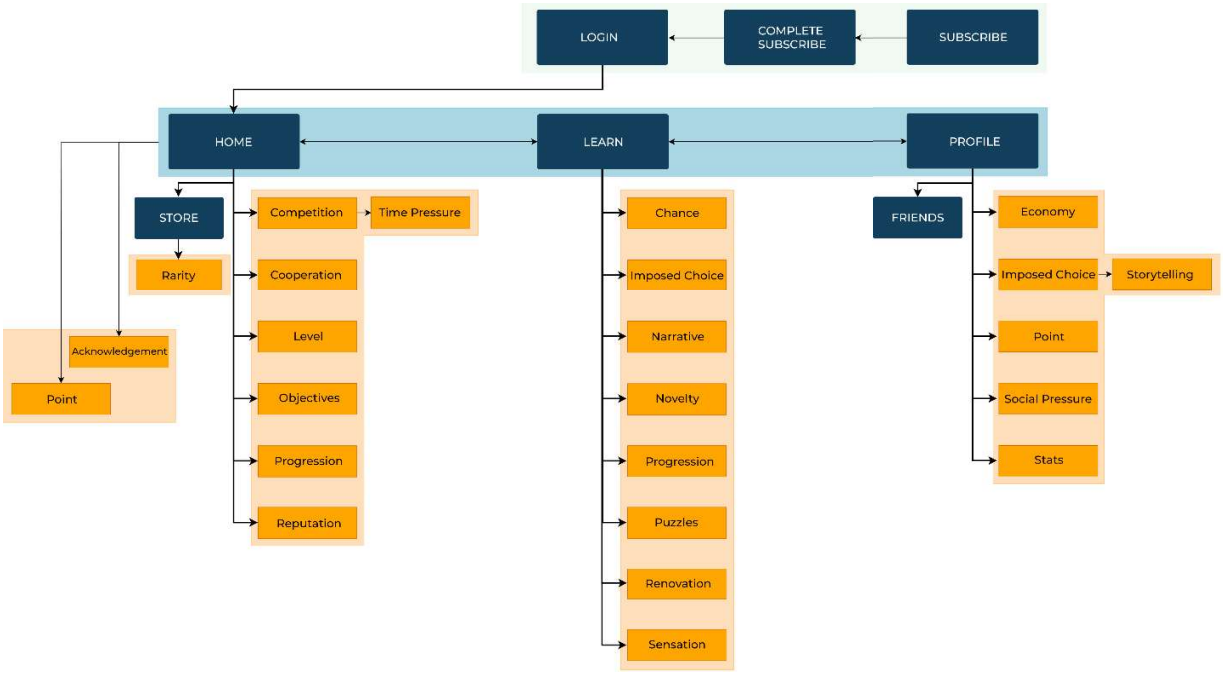

Figure 3. Gamification design flowchart

On the **Fourth Day** (prototype), the gamification design was discussed among all team members and all team members agreed with the proposal. Next, through another brainstorming session, the team defined the functions that would be present in the prototype. On the **Fifth Day** (test and validate), we analysed the prototype and tested the gamification elements interactions through decision tables testing, which is a common software development technique for defining software restrictions and events. It is a systematic method to test input combinations and their output (Jorgensen, 2013). An example of the Decision table testing can be seen in Table 3, where each "Event" row is an action that can be performed in the prototype and the following columns are the gamification elements that are affected by that action.

Table 3. Table testing example

Event	Point	Acknowledgement	Competition	Time Pressure	Social Pressure	Imposed Choice
A1: Student got a question right	Yes	Partially	Yes	No	Partially	No
A2: Student chose their avatar	No	No	No	No	No	Yes
A3: Student achieved a new rank on the leader board	Yes	Yes	Yes	Partially	Yes	No
A4: Student got 5 questions right in a sequence	Yes	Yes	Yes	No	Partially	No

An example on how to understand Table 3 is the first row, where A1 is the event "*Student got a question right*," triggered when the student is answering a question related to a certain content. When students answer correctly, they gain a ***Point***, which can be summed towards an Achievement (***Acknowledgement***), and towards the Leader Board (***Competition***). The update on the Leader Board can influence the ***Social Pressure*** in the system, since the student

can increase their rank or decrease it, affecting other students. Figure 4 demonstrates an interaction diagram of the events A1 and A4, to exemplify the approach.

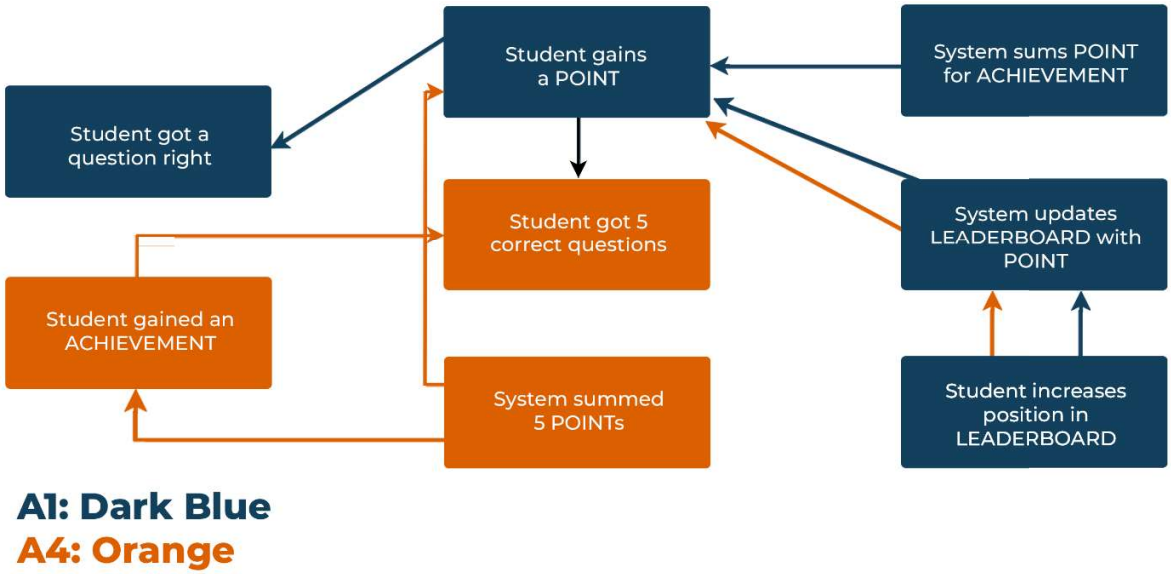

Figure 4. Interaction diagram to exemplify the decision table test

The system consists of three main pages: *Home*, where students can track their progress and evolution in the system; *Learn*, where students will have educational activities; and *Profile*, where students will have access to all their information. The *Home* page has a sub-page called *Store*, where students can buy special items. The *Learn* page has three task settings (missions), where students will have lessons. The *Profile* page has a sub-page called *Friends*, where students can view other members and follow them. These pages were designed using scenarios and evaluated using the persona technique, which is based on creating goal-directed, role-based and fictional users that will interact with the system (De Borba, Gasparini, & Lichtnow, 2017; Nielsen, 2013; Preece, Rogers, & Sharp, 2015). For example, Gareth, the undergraduate student and avid competitor, who tends to get questions wrong, and may not notice functionality of the system due to his impulsivity. Or Cynthia who likes to buy clothes in real-life, and is attracted by the store icon in the system, etc. This technique is used for testing prototypes and can aid designers to visualise the behaviours within the system. This technique has also been used to evaluate other gamified educational systems, as seen in Palomino et al (2019a).

An example for the gamification design is the implementation of the Point element is as follows: "*The Point element will be displayed on all pages (in the fixed header) and will be represented by experience points (XP). The student will earn seven (or a specific number according to the system specificities) points for each activity done and two extra points if the activity is done correctly (hit the answer). Points will be updated each time the student completes an activity group. The total points will also be highlighted on the Profile page*." Table 4 synthesises the proposed gamification design.

Table 4. Proposed gamification design

Concept	Design description
Acknowledgement	The Acknowledgment element should be displayed on all pages and will be represented through the achievement feedbacks. Thus, the user will receive immediate notifications of all achievements in the system.
Chance	The Chance element should appear on the Learn page and will consist of a random option offered to the user to increase their prize.

Competition	The Competition Element should be featured on the homepage and represented by weekly leaderboards with up to 10 students.
Cooperation	The Cooperation element should be featured on the Homepage and represented by the formation of random teams of up to 5 students.
Economy	The Economy element should appear on every page and represented by coins that can be used to make in-game purchases.
Imposed Choice	The Imposed Choice element should be displayed on the Profile page. When viewing their profile for the first time, users should be able to choose an avatar to represent them in the system. This avatar will evolve when using the system. In addition, the student should have to make different types of choices during use (e.g., choosing between chests with coins).
Level	The level element should be displayed on the Homepage, represented by phase (bronze, silver, gold, and diamond, respectively).
Narrative	The narrative element should be presented on the Learn page, represented by the user's ability to do extra activities. At times, when the user completes a quest, they may choose to visit other system pages or immediately do a new quest, for earning extra coins.
Novelty	The Novelty element should appear on the Learn page and the Store page. On the Learn page, it should be represented by hints that will be appear when the user misses a sequence of three questions in a row. On the Store page, it should be represented by selling special objects.
Objectives	The Objectives element should be displayed on the Homepage and should be represented by a quest tree. This tree can show the entire sequence of missions the student has in the system.
Point	The Point element should be displayed on all pages (in the fixed header) and should be represented by experience points (XP). The student should earn points for each activity done and extra points if the activity is done correctly (hit the answer).
Progression	The Progression element should be displayed on the Home and Learn pages and should be represented as a progress bar. The Homepage should be represented by a circular progress bar in the activity tree, indicating how much of each activity group has been completed and how much remains to be completed. In the Learn page it should be represented by a progress bar, showing how much has been completed and how much is left to complete each activity group.
Puzzles	The Puzzles element should be presented on the Learn page and should be represented by proposing (non-mandatory) surprise challenges, related to the subject being studied.
Rarity	The Rarity element should appear on the Store page and should be represented as a series of shields. Rare items should be available in the system store with purchase values that can be purchased through coins.
Renovation	The Renovation element should be displayed on the Learn page and should be represented through the possibility for students to perform activities in which they err. There should be no cost for students to redo the activities they have missed.
Reputation	The Reputation element should be displayed on the Homepage and should be represented by the student's title/patent display. Different hierarchical levels can be achieved through special sequences in the system.

Sensation	The Sensation element should be displayed on the Learn page and should be represented by immediate feedback (visual and audible) regarding each action/response from users, indicating whether they have hit or missed each question.
Social Pressure	The Social Pressure element should be displayed on the Profile page and should be represented by an alert message, whenever the user drops in the ranking (is exceeded by a colleague).
Stats	The Stats element should be present on the Profile page and should be represented by all user progress information, which by default will already be displayed on the Profile page.
Storytelling	The Storytelling element should be present on the Profile page, represented by the evolution of the avatar (and its story) of a student (thus associated with the Imposed Choice element).
Time Pressure	The Time Pressure element should be present on the Home page and should be represented by a weekly countdown (thus associated with the Competition element).

4. Discussions and limitations

Before starting the discussions related to our study, it is important to highlight that our study generated some limitations inherent to this type of study. Initially, because it is a critical and creative process, it is not possible to systematise all design decisions (e.g., document all discussions). To mitigate this limitation, we used a process known in the literature and used in similar studies (Design Sprint method). In the last step (***Fifth day***), it was not possible to perform an evaluation with users; however, we used the persona technique, which is a valid HCI technique.

Additionally, there is the limitation of implementing content elements from the Taxonomy by Toda et al., (2019a). By content elements we especially refer to Storytelling and Narrative (Kapp, 2012; Palomino et al., 2019b) that, although already mentioned in the literature, e.g., Marczewski's Periodic Table of Gamification Elements (Tondello et al., 2016) and Klock's gamification conceptual model (Klock et al., 2019), lack systematically validated procedures (e.g., frameworks or processes) guiding designers on how to implement them. For instance, Armstrong and Landers, (2017) investigated the impact of transforming regular texts into scripted texts, thereby making users interact with texts telling a story, which fits in the Storytelling game element (Toda et al., 2019b). Another example is Champagnat, Delmas and Augeraud, (2010) research which dealt directly with the Storytelling concept applied to learning. They presented a variation of Campbell's Hero Journey (Campbell, 2008), specifically, for interactive storytelling, and detailed how this model could be used in an educational context.

In these cases, authors often rely on some specific or self-developed framework/process for implementing those elements. Whereas there exist options for developing stories, which might be used for Storytelling (e.g., that used by Landers et al. (2017)), the literature still lacks a systematic process for adding the Narrative game element to GES, although research towards this direction has recently emerged (e.g., Marczewski, 2015; Palomino et al., 2019c). Thus, future studies maturing the field in terms of how to implement content game elements would benefit designers and, as using these elements along with other common game elements (e.g., Cooperation, Objectives and Puzzles) is of users' interest (Palomino et al., 2019b), their experiences would be benefited as well. Therefore, we call for further research on this topic.

Furthermore, defining which set of elements to use together was another challenging process. This happens due the lack of studies that provide clear guidelines and justifications on the combination of game elements, which has been pointed as an important aspect in the gamification design (Dichev & Dicheva, 2017; Toda et al., 2018b). On one hand, each element from the taxonomy used in this work has a specific goal and, therefore, is likely to be used in different occasions. On the other hand, there are some elements that have similar goals, as can be seen by their grouping shown in Figure 2. However, selecting which game elements to use together, by simply following their grouping, might not be the best option as, for instance, one might be seeking to create a gamification design (game

elements set) that involves showing users' performance (one group) based on their social interactions (another group). To define those sets, there are two high-level approaches that have been explored: theory- and data-driven insights.

While theory-driven approaches explore theories such as the self-determination theory (Deci & Ryan, 1985) to define which game elements to use, data-driven ones rely on, for instance, usage data to select the gamification design (Meder, Plumbaum, & Albayrak, 2017). On the other hand, the data-driven approaches have recently emerged, and scholars have defended their benefits over theory-driven ones, in the context of gamification (Meder et al., 2017) . Given this context, studies on how to define gamification designs based on data have started to appear (Toda et al., 2019c). Nevertheless, as this is a recent field study, it is yet to mature and further research is required to both improve the understanding on how to create those data-driven designs, as well as to identify whether those are more effective than theory-driven designs in affecting users' behaviour – or perhaps combined approaches are required.

Another recent, relevant issue of gamification designs that was not addressed by the design we presented in this study is personalisation. That is, providing gamification design tailored to different user types aiming at improving their experiences (Oliveira & Bittencourt, 2019). As gamified systems are a specific type of information systems, the personalisation dimension is an important aspect to be tackled (Klock, Ogawa, Gasparini, & Pimenta, 2018; Liu & Stacey, 2015). Personalisation emerges as an approach to accommodate different users within the same gamified systems (Seaborn & Fels, 2014), which is a necessary step, as users have different behaviours, interpretations, preferences, and experiences (Lavoué, Monterrat, Desmarais, & George, 2019; Orji, Tondello, & Nacke, 2018), thereby, the same gamification design is unlikely to work for all of them.

Thus, we highlight two closely related research veins that should be tackled. Future studies should further investigate whether the use of personalisation approaches can improve gamification's effectiveness, compared to generic design. The other is that personalisation approaches focusing not only on the users, but also on the task they are performing, should be performed, to provide gamified design aiming to satisfy users' preferences, as well as the task at hand. Consequently, creating guidelines on how to deploy it, which will then support practitioners deciding on how and whether to personalise the gamification designs of their systems.

Regarding the use of the Design Sprint method, it was noted that this method allowed team members to propose a solution rapidly and through a critical-creative approach, where team members were able to share opinions on each step of the solution proposal, and at the same time, criticise colleagues' proposals and self-criticise their propositions. Thus, it is possible to conduct further studies using this method and perform evaluations that can measure the effectiveness of the method in the gamification design process.

5. Conclusions and future work

This work presented a method on how we can use gamification elements to gamify learning environments. We compared our taxonomy with other works concerned with gamifying learning activities that were found through an existing systematic mapping. We also used an agile process alongside the given taxonomy. Through this work, we present a new way on how to gamify learning systems using methods different from other frameworks. We also believe that this taxonomy can be used within most existing frameworks in the education field, since its definitions cover most of the elements that exist in previous frameworks.

For future work, we are focusing on designing an experiment to research if this taxonomy can be used alongside data-driven gamified recommendations based on the elements that compose it. We intend to conduct a deeper analysis on the scenarios provided in Table 3, by using other types of evaluation besides the persona technique (e.g., students' evaluations of the system). We also intend to design a gamified educational system based on the gamification design proposed in this article and to conduct a longitudinal study assessing the students' experience in that system. We are especially interested to investigate the gamification influence in the students' flow experience and learning outcomes.

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References

Armstrong, M. B., & Landers, R. N. (2017). An Evaluation of Gamified Training: Using Narrative to Improve Reactions and Learning. *Simulation & Gaming, 48*(4), 513–538. doi:10.1177/1046878117703749

Borges, S. de S., Durelli, V. H. S., Reis, H. M., & Isotani, S. (2014). A systematic mapping on gamification applied to education. In *Proceedings of the 29th Annual ACM Symposium on Applied Computing - SAC '14* (pp. 216–222). doi:10.1145/2554850.2554956

Campbell, J. (2008). *The hero with a thousand faces*. Novato, California, USA: New World Library.

Champagnat, R., Delmas, G., & Augeraud, M. (2010). A storytelling model for educational games: Hero's interactive journey. *International Journal of Technology Enhanced Learning, 2*(1–2), 4–20. doi:10.1504/IJTEL.2010.031257

Csikszentmihalyi, M. (1975). *Flow: The Psychology of Optimal Experience*. Harper & Row. Retrieved from http://www.amazon.com/Flow-The-Psychology-Optimal-Experience/dp/0061339202

Darejeh, A., & Salim, S. S. (2016). Gamification Solutions to Enhance Software User Engagement – A Systematic Review. *International Journal of Human-Computer Interaction, 32*(8), pp 613-642. doi:10.1080/10447318.2016.1183330

De-Marcos, L., Domínguez, A., Saenz-de-Navarrete, J., & Pagés, C. (2014). An empirical study comparing gamification and social networking on e-learning. *Computers & Education, 75*, 82–91. doi:10.1016/j.compedu.2014.01.012

De Borba, E. J., Gasparini, I., & Lichtnow, D. (2017). The use of time dimension in recommender systems for learning. In *Proceedings of the 19th International Conference on Enterprise Information Systems (ICEIS 2017)* (Vol. 2, pp. 600–609). doi:10.5220/0006312606000609

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic Motivation and Self-Determination in Human Behavior*. Boston, MA: Springer US. doi:10.1007/978-1-4899-2271-7

Deterding, S., Sicart, M., Nacke, L., O'Hara, K., & Dixon, D. (2011). From Game Design Elements to Gamefulness: Defining "Gamification." In *Proceedings of the 2011 Annual Conference Extended Abstracts on Human Factors in Computing Systems - CHI EA '11* (pp. 2425-2428). doi:10.1145/1979742.1979575

Dichev, C., & Dicheva, D. (2017). Gamifying education: What is known, what is believed and what remains uncertain: a critical review. *International Journal of Educational Technology in Higher Education, 14*(1), 9. doi:10.1186/s41239-017-0042-5

Huotari, K., & Hamari, J. (2012). Defining gamification: a service marketing perspective. In *Proceeding of the 16th International Academic MindTrek Conference* (pp. 17–22). doi:10.1145/2393132.2393137

Jorgensen, P. C. (2013). *Software testing: A craftsman's approach, third edition. Software Testing: A Craftsman's Approach* (3rd ed.). New York, NY: Auerbach Publications. doi:10.1201/9781439889503

Kapp, K. M. (2012). *The Gamification of Learning and Instruction: Game-based Methods and Strategies for Training and Education*. San Francisco, CA: John Wiley & Sons.

Kasurinen, J., & Knutas, A. (2018). Publication trends in gamification: A systematic mapping study. *Computer Science Review, 27*, 33–44. doi:10.1016/j.cosrev.2017.10.003

Klock, A. C. T., Gasparini, I., & Pimenta, M. S. (2016). 5W2H Framework. In *Proceedings of the 15th Brazilian Symposium on Human Factors in Computer Systems - IHC '16* (pp. 1–10). New York, NY: ACM Press. doi:10.1145/3033701.3033715

Klock, A. C. T., Ogawa, A. N., Gasparini, I., & Pimenta, M. S. (2018). Does gamification matter? A systematic mapping about the evaluation of gamification in educational environments. In *Proceedings of the 33rd Annual ACM Symposium on Applied Computing* (pp. 2006–2012). New York, NY: ACM Press. doi:10.1145/3167132.3167347

Klock, Ana Carolina Tomé, Gasparini, I., & Pimenta, M. S. (2019). User-Centered Gamification for E-Learning Systems: A Quantitative and Qualitative Analysis of its Application. *Interacting with Computers, 31*(5), 425-445. doi:10.1093/iwc/iwz028

Koivisto, J., & Hamari, J. (2019, April 1). The rise of motivational information systems: A review of gamification research. *International Journal of Information Management, 45*, 191-210. doi:10.1016/j.ijinfomgt.2018.10.013

Kotini, I., & Tzelepi, S. (2015). A Gamification-Based Framework for Developing Learning Activities of Computational Thinking. In *Gamification in Education and Business* (pp. 219–252). doi:10.1007/978-3-319-10208-5_12

Landers, R. N. (2019). Gamification Misunderstood: How Badly Executed and Rhetorical Gamification Obscures Its Transformative Potential. *Journal of Management Inquiry, 28*(2), 137–140. doi:10.1177/1056492618790913

Lavoué, É., Monterrat, B., Desmarais, M., & George, S. (2019). Adaptive Gamification for Learning Environments. *IEEE Transactions on Learning Technologies, 12(*1), 16–28. doi:10.1109/TLT.2018.2823710

Lee, J. J., & Hammer, J. (2011). Gamification in Education: What, How, Why Bother? *Academic Exchange Quarterly, 15*, 1–5.

Liu, L., & Stacey, P. (2015). Development Process of Intrinsic Gamification in a Learning Difficulty Context. In *UK Academy for Information Systems Conference Proceedings 2015,* 4. Retrieved from http://aisel.aisnet.org/ukais2015/4

Marczewski, A. (2015). *Even Ninja Monkeys Like to Play: Gamification, Game Thinking and Motivational Design*. London, United Kingdom: Blurb.

Martí-Parreño, J., Seguí-Mas, D., & Seguí-Mas, E. (2016). Teachers' Attitude towards and Actual Use of Gamification. *Procedia - Social and Behavioral Sciences, 228*, 682–688. doi:10.1016/j.sbspro.2016.07.104

Meder, M., Plumbaum, T., & Albayrak, S. (2017). A Primer on Data-Driven Gamification Design. In *Proceedings of the Data-Driven Gamification Design Workshop* (pp. 12-17). Retrieved from https://pdfs.semanticscholar.org/c8dd/744530be00bc3b12046b60facb4b1bd47137.pdf

Mora, A., Riera, D., González, C., & Arnedo-Moreno, J. (2017). Gamification: A Systematic review of design frameworks. *Journal of Computing in Higher Education, 29*(3), 516-548. doi:10.1007/s12528-017-9150-4

Mora, A., Zaharias, P., González, C., & Arnedo-Moreno, J. (2016). FRAGGLE: A framework for agile gamification of learning experiences. In *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)* (Vol. 9599, pp. 530–539). doi:10.1007/978-3-319-40216-1_57

Nielsen, J., & Landauer, T. K. (1993). A mathematical model of the finding of usability problems. In *Proceedings of the SIGCHI conference on Human factors in computing systems - CHI '93* (pp. 206–213). New York, NY: ACM Press. doi:10.1145/169059.169166

Nielsen, L. (2014). Personas. In *Encyclopedia of Human-Computer Interaction*, 1-37. Available in: https://www.interaction-design.org/literature/book/the-encyclopedia-of-human-computer-interaction-2nd-ed/personas

Oliveira, W., & Bittencourt, I. I. (2019). Tailored Gamification to Educational Technologies. Tailored Gamification to Educational Technologies. Singapore: Springer Singapore. doi:10.1007/978-981-32-9812-5

Orji, R., Tondello, G. F., & Nacke, L. E. (2018, April). Personalizing persuasive strategies in gameful systems to gamification user types. In *Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (pp. 1-14).

Palomino, P. T., Toda, A. M., dos Santos, W. O., Cristea, A. I., & Isotani, S. (2019a). Narrative for gamification in education: why should you care? In *Proceedings of the 19th IEEE International Conference on Advanced Learning Technologies* (pp. 97-99). Maceió, Brazil: IEEE Computer Society.

Palomino, P. T., Toda, A. M., Oliveira, W., Rodrigues, L., & Isotani, S. (2019b). Gamification Journey : A Novel Approach for Classifying Gamer Types for Gamified Educational Systems. In *Proceedings of SBGames 2019*. Rio de Janeiro, Brazil: Sociedade Brasileira de Computação.

Palomino, P. T., Toda, A., Oliveira, W., Rodrigues, L., Cristea, A. I., & Isotani, S. (2019c). Exploring Content Game Elements to Support Gamification Design in Educational Systems: Narrative and Storytelling. In *Proceedings of the SBIE 2019* (pp. 773–782). doi:10.5753/cbie.sbie.2019.773

Paula, F. R. De, & Fávero, R. da P. (2016). A gamificação da educação na compreensão dos profissionais da educação [The gamification of education in the perspective of education professionals]. In *SBC - Proceedings of SBGames 2016* (pp. 1459–1465). São Paulo, Brazil: Sociedade Brasileira de Computação.

Pedreira, O., García, F., Brisaboa, N., & Piattini, M. (2015). Gamification in software engineering - A systematic mapping. *Information and Software Technology, 57*(1), 157–168. doi:10.1016/j.infsof.2014.08.007

Preece, J., Rogers, Y., & Sharp, H. (2015). *Interaction design: beyond human-computer interaction*. Edinburgh Gate Harlow, United Kingdom: John Wiley & Sons.

Sánchez-Mena, A., & Martí-Parreño, J. (2016). Gamification in higher education: teachers' drivers and barriers. In *Proceedings of the International Conference of The Future of Education*, (July). Florence, Italy: Libreriauniversitaria.it.

Seaborn, K., & Fels, D. I. (2014). Gamification in Theory and Action: A Survey. *International Journal of Human-Computer Studies, 74*, 14–31. doi:10.1016/j.ijhcs.2014.09.006

Simões, J., Redondo, R. R. D., & Vilas, A. A. F. (2013). A social gamification framework for a K-6 learning platform. Computers in Human Behavior, 29(2), 345–353. doi:10.1016/j.chb.2012.06.007

Sumual, H., Batmetan, J. R., & Kambey, M. (2019). Design Sprint Methods for Developing Mobile Learning Application. *KnE Social Sciences, 3*(12), 394–407. doi:10.18502/kss.v3i12.4106

Thiebes, S., Lins, S., & Basten, D. (2014). Gamifying information systems A synthesis of gamification mechanics and dynamics. In *Proceedings of the Twenty Second European Conference on Information Systems* (pp. 1–17). Retrieved from http://aisel.aisnet.org/ecis2014/proceedings/track01/4/

Toda, A. M., Valle, P. H. D. D., & Isotani, S. (2018b). The Dark Side of Gamification: An Overview of Negative Effects of Gamification in Education. In *Communications in Computer and Information Science* (Vol. 832, pp. 143–156). doi:10.1007/978-3-319-97934-2_9

Toda, A. M., do Carmo, R. M. C., da Silva, A. P., Bittencourt, I. I., & Isotani, S. (2018a). An approach for planning and deploying gamification concepts with social networks within educational contexts. *International Journal of Information Management, 46*, 294-303. doi:10.1016/J.IJINFOMGT.2018.10.001

Toda, A. M., Klock, A. C. T., Oliveira, W., Palomino, P. T., Rodrigues, L., Shi, L., Gasparini, I., Bittencourt, I., I., Isotani, S., Cristea, A. I. (2019b). Analysing gamification elements in educational environments using an existing Gamification taxonomy. *Smart Learning Environments, 6*(1), 16. doi:10.1186/s40561-019-0106-1

Toda, A. M., Oliveira, W., Klock, A. C., Palomino, P. T., Pimenta, M., Gasparini, I., Shi, L., Bittencourt, I. I., Isotani, S., Cristea, A. I. (2019a). A Taxonomy of Game Elements for Gamification in Educational Contexts: Proposal and Evaluation. In *2019 IEEE 19th International Conference on Advanced Learning Technologies (ICALT)* (pp. 84-88). doi:10.1109/ICALT.2019.00028

Toda, A. M., Oliveira, W., Shi, L., Bittencourt, I., Isotani, S., & Cristea, A. (2019c). Planning Gamification Strategies based on User Characteristics and DM: A Gender-based Case Study. In *Proceedings of the Educational Data Mining 2019 conference* (pp. 438–443). Montréal. Retrieved from http://arxiv.org/abs/1905.09146

Toda, A., Palomino, P., Rodrigues, L., Oliveira, W., Shi, L., Isotani, S., & Cristea, A. (2019d). Validating the Effectiveness of Data-Driven Gamification Recommendations: An Exploratory Study. In *Anais do XXX Simpósio Brasileiro de Informática na Educação (SBIE 2019)* (Vol. 30, pp. 763-772). doi:10.5753/cbie.sbie.2019.763

Tondello, G. F., Wehbe, R. R., Diamond, L., Busch, M., Marczewski, A., & Nacke, L. E. (2016). The Gamification User Types Hexad Scale. In *Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play - CHI PLAY '16* (pp. 229–243). doi:10.1145/2967934.2968082

Vargas-Enriquez, J., Garcia-Mundo, L., Genero, M., & Piattini, M. (2015). A Systematic Mapping Study on Gamified Software Quality. In *Proceeding of the 7th International Conference on Games and Virtual Worlds for Serious Applications (VS-Games)* (pp. 1–8). doi:10.1109/VS-GAMES.2015.7295763

Wongso, O., Rosmansyah, Y., & Bandung, Y. (2014). Gamification framework model, based on social engagement in e-learning 2.0. In *Proceedings of the 2nd International Conference on Technology, Informatics, Management, Engineering, and Environment (TIME-E)* (pp. 10–14). doi:10.1109/TIME-E.2014.7011583

Zichermann, G., & Cunningham, C. (2011). *Gamification by Design: Implementing Game Mechanics in Web and Mobile Apps* (1st ed.). Sebastopol, CA: O'Reilly Media.

ANNEX

K

PLANNING GAMIFICATION STRATEGIES BASED ON USER CHARACTERISTICS AND DM: A GENDER-BASED CASE STUDY

Planning Gamification Strategies based on User Characteristics and DM: A Gender-based Case Study

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ABSTRACT

Gamification frameworks can aid in gamification planning for education. Most frameworks, however, do not provide ways to select, relate or recommend how to use game elements, to gamify a certain educational task. Instead, most provide a "one-size-fits-all" approach covering all learners, without considering different user characteristics, such as gender. Therefore, this work aims to adopt a data-driven approach to provide a set of game element recommendations, based on user preferences, that could be used by teachers and instructors to gamify learning activities. We analysed data from a novel survey of 733 people (male=569 and female=164), collecting information about user preferences regarding game elements. Our results suggest that the most important rules were based on four (out of nineteen) types of game elements: Objectives, Levels, Progress and Choice. From the perspective of user gender, for the female sample, the most interesting rule associated Objectives with Progress, Badges and Information (confidence=0.97), whilst the most interesting rule for the male sample associated also Objectives with Progress, Renovation and Choice (confidence=0.94). These rules and our descriptive analysis provides recommendations on how game elements can be used in educational scenarios.

1. INTRODUCTION

Gamification has been a widely popular phenomenon in the past few years, being used in various domains, including that of education. Gamification is defined as the use of game elements outside their scope (*i.e.*, games or game playing) [1, 2]. However, educators often may not be familiar with specific game-related concepts, or know how to use game elements, or may not have the resources or time necessary [3, 4, 5]. A solution is to employ conceptual gamification frameworks [6]. Still, existing frameworks lack resources and explanations on how to use game elements appropriately [5], especially when considering user preferences affected by demographic differences. Understanding users' characteristics, such as gender, may be especially beneficial, *e.g.*, in STEM education, where the well-known problem of 'the leaking STEM pipeline'[1] occurs [7].

In this paper, we apply a data-driven approach to provide insights into the educational domain, via the research question: *"How can gender differences in preferences about gamification elements be used to support gamification design?"* We conducted a very large survey (808 raw answers) allowing respondents to rank gamification elements. We based these elements on the works of Dignan [8] and Toda *et al.* [5], due to (a) the relatively large number and variety of elements, (b) the availability of synonyms used. Next, we used an unsupervised learning algorithm to generate Association Rules to find patterns within the dataset, in order to understand relations among these elements, based on the users' genders. Our main contributions are: (a) a survey[2] for extracting preferences for gamification for education, applied to a large, varied number of respondents; (b) extracting gamification elements relevant to the different genders, for the educational domain; (c) extracting relations between these elements, relevant to the different genders; (d) insights into users' acceptance of specific game elements, or groups thereof (and their relations).

2. RELATED WORKS

As there are very few frameworks focusing on gamification in education domains, we discuss: *(i)* existing models related to game elements, *(ii)* gamification studies on user characteristics, *(iii)* planning of gamification.

[1] dropout in STEM education
[2] `https://forms.gle/hFgTT7kCqBKLqiPd8`

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Yee and Marczewski both proposed models on how to use game elements,using also large data collections [9, 10]; however, their focus is different: they collected (a) players' motivations towards online RPGs and (b) generic gamified applications. [10] only provides recommendations of elements for behavioural profiles, but not user demographic characteristics, such as gender. Yee's model additionally analysed behaviours from a gender perspective, but only fo online RPG (World of Warcraft) players exclusively. A recent study by Shi and Cristea [11, 12] proposed a model and a set of recommendations based on the Self-Determination Theory [13]. Their Motivational Gamification Strategies related game elements with each construct of the SDT, *i.e.*, Autonomy, Competence and Relatedness, and implemented them [11], achieving positive results for each construct. Such studies show how motivational theories and gamification constructs can be related, as well support gamification in education. They however do not support the design process of gamification for educators and teachers.

Denden *et al.* [14] conducted an experiment analysing user preferences (N = 120) over eight game elements within a gamified educational system, based on personality traits (the famous 'Big Five' [15]). According to the authors, only extraversion, openness and conscientiousness affected students' preferences for particular game elements. The authors also stated the importance of this kind of recommendation to designers and instructors when gamifying their learning environments. However, the gamification in education literature lacks studies which relate the acceptance and influence of game elements with users' genders, involving large-scale data [16]. One recent study [17] conducted an experimental study aiming at identifying differences between male and female users (N = 70) towards 'gaming the system' behaviours. It was shown that game elements led to male users decreasing their undesired behaviours; moreover, female users felt less competent than male users. Nevertheless, although the results are interesting, the number of students who were analysed is still relatively small, with students from within a course context - whereas our study has a wider scale and variety of participants.

Toda *et al.* [5] proposes a framework for blended classroom environments using social networks, via a list of recommendations (names of gamified strategies) based on previous studies in gamification in education. They also apply Dignan's game elements classification [8]. However, the gamified strategies proposed are solely based on literature. Nevertheless, their positive results show that game elements are suited for educational environments (*e.g.*, classroom and digital platforms). As noted, other gamification frameworks focused on specific domains (*e.g.* Computational Thinking [18]). Klock et al [19]'s framework is usable for adaptive system. Still, Mora et al [6] note that this framework focuses on the researchers, rather than the stakeholders (teachers and instructors) and presents limited recommendations on game elements usage.

Thus, whilst gamification shows potential benefits for educational applications, the gender differences in preference towards specific game elements needed further, large-scale, systematic studies, to better provide support for Data-Driven Gamification Design, as tackled by our current paper.

3. DATASET AND METHODS

Our survey on game elements contains 29 questions. The first part collected demographic information (age, favourite game setting, and gender). The second part asked to what extend certain game elements were relevant to users in the gamified educational system context, through a Likert Scale, from 1 "I think this element is irrelevant to me" to 5 "I think this element is highly relevant to me". The game elements used and their advantages and potential drawbacks are presented in `https://tinyurl.com/y44kqvn5` based on [8] and used in [5] in an educational domain.

Additionally to theoretical motivations, we further validated the selected gamification elements with 4 specialists in gamification, who were also teachers, via an interview, verifying the specialists' acceptance of the used elements, concepts, as well as questions cohesion. Finally, a pilot survey with 18 people verified the time spent and the consistency of the questions, before launching the main survey `https://goo.gl/forms/dOi5WosBcMVWvQAK2`. We then recruited surveyees through social networks, forums and digital environments used by people who play games.

In total, we collected 808 raw answers. Further cleaning removed data from users who: (a) did not answer all questions; (b) claimed not having played any digital games; (c) were of age<0 or age>90. Then, we analysed our population characteristics based on demographic data. As the normality test showed a non-normal distribution, a Mann-Whitney test [20] was used to compare males and females.

Finally, we used association rule mining to analyse the relations amongst our data, based on gender. Unsupervised learning was used as we do not have any predefined labels (outputs) and also to understand the relations between the elements (different from clustering which create groups based on all variables of the dataset).The algorithm analyses the items' frequency (support) and renders a level of confidence, ranging from 0 to 1 (where 1 is the maximum confidence). The confidence can also be supported by conviction [21], lift and leverage -– both measuring the independence of items.

4. RESULTS AND DISCUSSION

4.1 Gender differences

After filtering, we retrieved 733 valid answers (90.72%). We applied Cronbach's α on the second group of questions (as game elements were based on a Likert scale) and achieved an $\alpha = 0.83$ (high reliability factor [22]). Our sample is varied in terms of age (ranging from 13 to 68), but limited in terms of experience in playing (at least a year: by design and filtering) and country of origin (Brazil; due to convenience sampling). Nevertheless, the sampling size is much larger than the recommended one (733 >> 384; people playing online games estimated at 700 mio; confidence level 95%).

We further organised our valid answers into two groups: males (N = 569) and females (N = 164), and verified the distribution of the data using the Shapiro-Wilk normality test. The result showed that our data rejected the null hypothesis ($p < 0.05$), so we adopted non-parametric tests in further analyses. Table 1 summarises the result.

Table 1: Relevance of game elements, averaged per gender

	Gender (mean)		Mann-Whitney	
Element	**Female**	**Male**	**W**	**p-value**
Point	3.76	3.68	44836	0.429
Level	4.14	4.21	48418	0.427
Cooperation	3.62	3.86	52306	0.013
Competition	3.26	3.56	53016	0.006
Renovation	4.16	3.78	35878	2.36e-03
Progress	4.24	4.32	48856	0.312
Objective	4.41	4.4	45902	0.791
Puzzles	4.14	3.91	40636	0.008
Novelty	4.05	4.16	49530	0.197
Chances	3.68	3.61	44901	0.447
Social Pressure	3.43	3.65	51142	0.05
Acknowledgement	3.85	3.73	44673	0.387
Data	4.05	4.09	46675	0.994
Scarcity	3.16	3.42	52468	0.011
Choice	4.07	4.23	50267	0.08
Time Pressure	3.16	2.97	42711	0.09
Economy	3.41	3.42	46738	0.973
Sensation	3.62	3.1	37094	1.17e-02
Classification	3.51	3.72	51340	0.042

Table 1 shows many significant differences (p-value < 0.05). Interestingly, Competition, Cooperation, Social Pressure, Scarcity and Classification were considered slightly more relevant by the males, whilst Renovation, Puzzle and Sensation elements were considered more relevant by females. Time pressure was disliked by males, but not as much by females.

4.2 Descriptive Analysis

Comparing surveyees, for elements preferred in different proportions, which are statistically significant between males and females, Cooperation was more relevant to males (57.3%); with 41.6% males selecting highly relevant, vs. 31.1% females (Table 2).

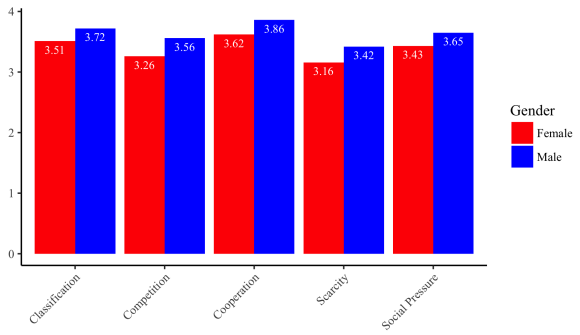

Figure 1: Favourite game elements for males (a,b-correspond to Tables 2,3, rsp.)

A more drastic difference appeared when more than 25% of the females did not consider Competition to be relevant, versus 54.5% males. This result suggests that males may perceive social interactions, such as Competition elements and Cooperation, as highly relevant overall in games, with a slight preference of Competition. For females, however, Competition is not that relevant, but, surprisingly, Cooperation is only marginally relevant. Social Pressure is significantly less liked by females (difference of 7.7%).

Table 2: Cooperation, Competition and Social Pressure answers.

	Cooperation				Competition				Social Pressure			
Sc	**F**	**%**	**M**	**%**	**F**	**%**	**M**	**%**	**F**	**%**	**M**	**%**
1	12	7.3	37	6.5	20	12.2	42	7.4	14	8.5	32	5.6
2	20	12.2	53	9.3	25	15.2	80	14.1	26	15.8	63	11.1
3	38	23.8	100	17.6	44	26.8	137	24.1	45	27.4	146	25.7
4	43	26.2	142	25	43	26.2	135	23.7	34	20.7	160	28.1
5	51	31.1	237	41.6	32	19.5	175	30.8	45	27.4	168	29.5

Scarcity was instead favoured (significantly) by males (Table 3), where 37.8% of the females are indifferent. Classification, also a social element, was considered significantly more relevant by males. 50.6% of the females considered it relevant, against 60.6% males (Table 3). Based solely on our descriptive analysis, we observed that the male population considered limited or rare tasks, allowing, *e.g.*, rewards such as interaction or collecting titles, as relevant. Again, in practice, this information allows the teachers to create titles for completing specific tasks during their lectures *e.g.*, by giving a title of 'Speedster' to the student who completes a list of task correctly and quicker than the others.

Table 3: Scarcity and Classification answers

	Scarcity				Classification			
Sc	**F**	**%**	**M**	**%**	**F**	**%**	**M**	**%**
1	16	9.8	32	5.6	13	7.9	25	4.4
2	25	15.2	78	13.7	14	8.5	68	11.9
3	62	37.8	189	33.2	54	32.9	131	23
4	39	23.8	161	28.3	42	25.6	163	28.6
5	22	13.4	109	19.2	41	25.0	182	32.0

As for the elements most favoured by females (Figure 2), Renovation scored highest. 76.2% said it was relevant, with 50% considering it highly relevant. In contrast, only 30.0% of the males considered it highly relevant, with almost 30% indifferent (Table 4). In a learning context, this may tell the teacher that female students might be more pleased with features as "continue", "try again" or be given 'extra lives'.

Another element highly relevant to females was Puzzles: 80.8%, against 68.1% of males; with 21.9% males indifferent. Again, females, in this scope, considered that testing their skills was more relevant than males did. The Puzzle and Renovation elements, when combined in practice, allow problem solving, with the opportunity to correct mistakes.

Finally, the Sensation element was considered more relevant by females. More than half (54.8%) of the female sample considered it relevant, against 42.5% of the males. This could be explained by Sensation being related to the user experience [8], and, based on Table 4, we can infer that the most relevant elements for the female sample were related to the experience, rather than social ones. This means that they may perceive tasks that involve their senses, *e.g.*, with a visual or phonetic appeal, as more relevant, which could further be redone whenever they wish, to improve a certain skill through challenges. In practice, this means that using materials and resources that are more visual appealing may be more pleasant to female students than the male ones.

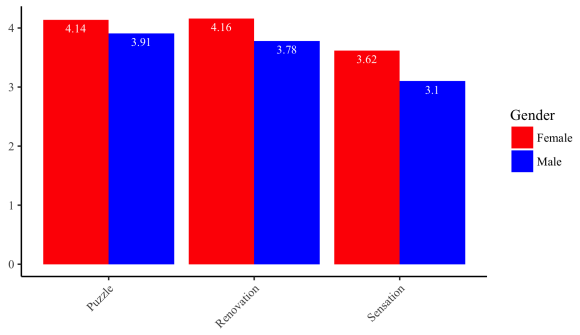

Figure 2: Favourite game elements for the female sample

Table 4: Renovation, Puzzle and Sensation answers

	Renovation				Puzzle				Sensation			
Sc	**F**	**%**	**M**	**%**	**F**	**%**	**M**	**%**	**F**	**%**	**M**	**%**
1	4	2.4	14	2.5	5	3	17	3	12	7.3	108	19
2	9	5.5	39	6.8	8	4.9	40	7	21	12.8	97	18
3	26	15.8	167	29.3	20	12.2	125	22	41	25	122	21.4
4	43	26.2	161	28.3	57	34.8	180	31.6	34	20.7	115	20.2
5	82	50	188	33	74	45.2	207	36.4	56	34.1	127	22.3

4.3 Association Rules analysis

To identify the strongest rules for each gender and to verify how the rules found matched or complemented the findings from our descriptive analysis (Section 4.2), we used the Apriori algorithm in Weka, with: *(i)* minimum support of 10% for the male sample size and 20% for female (to balance sample sizes); *(ii)* minimum confidence of 90%; and, after applying those attributes, *(iii)* we used the measures of interest *conviction*, *lift* and *leverage* to find the most interesting rules [23]. Using this setting we found a total of 11 rules for the female sample and 13 rules in the male one.

The majority (>90%) of the rules were based on the Objective element, which suggests its overall popularity. This translates into a general recommendation towards using 'Objective' elements in the educational gamification design, such as missions, milestones and quests, to guide the students. In this work we focused on analysing the most interesting rules in female and male samples. For females, the strongest rules were associated with the Objective (Table 5). The lift > 1 and leverage near 0 indicate that our items are independent and have a positive correlation, and the conviction between 1 and 5 indicates that these are interesting rules. The strongest rule relates Progress, Acknowledgement and Data elements (*e.g.*, Representations of progression, badges and medals and results screen) with Objective (*e.g.*, missions and quests). Rules regarding Progress and Level were also amongst the 10 strongest. Thus, we can suggest that teachers and instructors should use Acknowledgement (such as badges and trophies), with other elements associated with the personal enhancement of users (Progress and Level).

As for the male sample, Objective was also the main element but, in contrast to the females, we did not find any rules (with confidence $> 90\%$) related to elements that were most relevant to the male population (Table 6). There was only 1 rule that specified a social element (Social Pressure) amongst all the 14 rules. We can observe that Progress appears in almost all the rules, followed by Choice, appearing in seven rules. This means that, in our sample, designers and teachers should consider quests and missions that contain a form of progression and allow the students to make meaningful choices; those choices can be tied to a challenge (Rule 14), to transactions (Rule 24) and points (Rule 16).

Based on the data on Tables 5 and 6, we can observe that Objective associated to Progress is a concept that is (generally) well accepted by both genders. This means that teachers and designers should focus on, *e.g.*, developing quests (which can be tied to their original learning objectives) that allow the learners to place themselves within the task. This is important, since in some educational context, students do not know why they are learning a specific content; and consequently, may become demotivated [24]. In practice, this means that teachers can create milestones or goals, allowing students to visualise their progress towards this goal. Thus, guidelines can be provided to teachers, to convert their objectives in their classes into milestones or quests. Additionally, other representations of Progress, showing the users where they are in the course could be implemented, such as those supported by Levels, Points and Data.

4.4 Further Discussion

We consider this work to be important, as, with the advent of 'big data', various theoretical assumptions and statements can now be backed up by (significant) evidence. In the case of game elements, there is firstly a vast (not always research-based) evidence that games are linked to motivation, and keep players 'in the flow' [25]. Some studies even link specific game elements to higher levels of commitment or motivation [9]. Based on this evidence, as well as theories of motivation, gamification has been proposed for education. Currently, however, the data supporting these assumptions is scarce. There is a lot of small-scale empirical evidence, at classroom-scale, of approaches that showed mixed successes [26, 27]. In a similar way, there is evidence that gamification can also have undesirable effects [28]. This clearly points to the fact that there are parameters which need taken into consideration, which may influence the outcomes of gamified approaches to education. In this study, we specifically focus on demographic parameters - namely, gender.

Gender in education has been brought to the fore recently, with the advent of initiatives such as the 'Athena SWAN'[3] initiative towards gender equality in Higher Education in the UK, as well as similar initiatives world-wide. Importantly, equality doesn't mean 'one size fits all': on the contrary, gender equality means that the provision of education takes into account specific preferences that may be gender related. In a similar vein, certain types of games appeal to certain demographics and not others. For instance, card-related games are potentially more appealing to women, and first-player-shooter games to men (although, of course, preferences can vary) [29].

Further analysis of Table 1 shows that male and female preferences of some elements is relatively similar; e.g., Data, Economy, Objective are almost identical, and some are only

[3]https://www.ecu.ac.uk/equality-charters/athena-swan/

Table 5: Relevant association rules for female sample

Rule ID	If	Then	Conf	Lift	Lev	Conv
1	{progress, acknowledgement, data}	{objective}	0.97	1.63	0.08	7.04
2	{level, progress, acknowledgement}	{objective}	0.97	1.62	0.08	6.84
3	{progress, acknowledgement}	{objective}	0.96	1.6	0.1	6.04
4	{level, acknowledgement}	{objective}	0.95	1.59	0.09	5.5
5	{point, acknowledgement}	{objective}	0.95	1.58	0.08	4.96
6	{progress, puzzles}	{objective}	0.94	1.57	0.1	4.73
7	{puzzles, novelty}	{objective}	0.92	1.54	0.07	3.82
8	{novelty, acknowledgement}	{objective}	0.92	1.54	0.07	3.72
9	{acknowledgement, choice}	{objective}	0.92	1.54	0.07	3.72
10	{acknowledgement, data}	{objective}	0.91	1.52	0.08	3.54
11	{puzzles, acknowledgement}	{objective}	0.9	1.51	0.08	3.38

Table 6: Relevant rules to male sample

Rule ID	If	Then	Conf	Lift	Lev	Conv
12	{renovation, progress, choice}	{objective}	0.94	1.6	0.04	5.37
13	{progress, social pressure, data}	{objective}	0.93	1.59	0.04	5.04
14	{progress, puzzles, acknowledgement}	{objective}	0.93	1.59	0.05	5.16
15	{level, renovation, progress}	{objective}	0.93	1.59	0.04	4.96
16	{point, objective, puzzles}	{level}	0.92	1.93	0.05	5.74
17	{level, progress, puzzles, choice}	{objective}	0.92	1.57	0.04	4.27
18	{progress, acknowledgement, data}	{objective}	0.91	1.55	0.05	4.13
19	{point, progress, choice}	{objective}	0.91	1.55	0.04	4.01
20	{progress, novelty, data, choice}	{objective}	0.91	1.55	0.04	4.01
21	{progress, novelty, acknowledgement, choice}	{objective}	0.91	1.55	0.04	3.95
22	{renovation, progress, novelty}	{objective}	0.91	1.55	0.04	3.92
23	{level, progress, data, choice}	{objective}	0.91	1.55	0.04	3.92
24	{progress, novelty, economy}	{objective}	0.91	1.54	0.04	3.78
25	{progress, choice, economy}	{objective}	0.91	1.54	0.04	3.78

slightly different. Thus, some game elements may be perceived similarly by males and females - which makes the teacher's job much easier, in terms of design choices. This also puts more emphasis on the game elements where large differences exist, as well as on game elements where the differences in preference are slight, but statistically relevant.

Some of the results obtained were surprising: for instance, we expected females to appreciate cooperation more than males, but results (see section 4.2) showed otherwise. We did, on the other hand, obtain the expected results in terms of preference for competition. It is possible that online social interaction overall is perceived differently by males and females; for instance, females may perceive any type of social interaction online, where people are not known in advance, and anyone from anywhere can participate, as potentially threatening. These types of areas need further analysis.

For educational applications, it may seem that such potential 'fears' are less likely in controlled (classroom, or classroom-based) environments. However, for example, on Massive Online Open Courses (MOOCs), where people can participate from anywhere, such issues can again prevail. In fact, research on social interactions on MOOCs (e.g., comments, etc.) shows a predominance of males performing such activities. In contrast, females preferred puzzles (which can be solved also as solo-player) and the 'Renovation' element (see Figure 2), which allow for an independent style of play where one focuses only on ones own progress, instead of being interrupted by others.

5. CONCLUSIONS

This work presents our approach based on DDGD, towards planning of gamification in the educational information systems domain by using data mining. The main contribution of our work is to present a poll of gamified strategies tied to male and female genders. Furthermore, we use real data to aid in the decision process of teachers and instructors is selecting gamification strategies. Through our data, we could identify that males would make more use of social interactions, with strong confidence rules pairing gamification elements Progression and Choice. For the females, we identified that user experience and rewards are more relevant, with association rules indicating a strong confidence for the need of Acknowledgement and Progression. We believe that this work can impact the way teachers perceive and apply gamification in their environments, consequently improving students' engagement and motivation through a game-like experience.

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6. REFERENCES

[1] S. Deterding, M. Sicart, L. Nacke, K. O'Hara, and D. Dixon, "From Game Design Elements to Gamefulness: Defining "Gamification"," *Proceedings of the 2011 annual conference extended abstracts on Human factors in computing systems - CHI EA '11*, p. 2425, 2011.

[2] K. Seaborn and D. I. Fels, "Gamification in Theory and Action: A Survey," *Internatoinal Journal of Human-Computer Studies*, vol. 74, pp. 14–31, 2014.

[3] J. Martí-Parreño, D. Seguí-Mas, and E. Seguí-Mas, "Teachers' Attitude towards and Actual Use of Gamification," *Procedia - Social and Behavioral Sciences*, vol. 228, pp. 682–688, jul 2016.

[4] A. Sánchez-Mena and J. Martí-Parreño, "Gamification in higher education: teachers' drivers and barriers," *Proceedings of the International Conference of The Future of Education*, no. July, 2016.

[5] A. M. Toda, R. M. do Carmo, A. P. da Silva, I. I. Bittencourt, and S. Isotani, "An approach for planning and deploying gamification concepts with social networks within educational contexts," *International Journal of Information Management*, oct 2018.

[6] A. Mora, D. Riera, C. González, and J. Arnedo-Moreno, "Gamification: a systematic review of design frameworks," *Journal of Computing in Higher Education*, 2017.

[7] A. van den Hurk, M. Meelissen, and A. van Langen, "Interventions in education to prevent STEM pipeline leakage," *International Journal of Science Education*, vol. 41, no. 2, pp. 150–164, jan 2018.

[8] A. Dignan, *Game Frame*. Free Press, 2011.

[9] N. Yee, "Motivations for Play in Online Games," *CyberPsychology & Behavior*, vol. 9, no. 6, pp. 772–775, dec 2007.

[10] G. F. Tondello, R. R. Wehbe, L. Diamond, M. Busch, A. Marczewski, and L. E. Nacke, "The Gamification User Types Hexad Scale," in *Proceedings of the 2016 Annual Symposium on Computer-Human Interaction in Play - CHI PLAY '16*. New York, New York, USA: ACM Press, 2016, pp. 229–243.

[11] L. Shi, A. I. Cristea, S. Hadzidedic, and N. Dervishalidovic, "Contextual Gamification of Social Interaction – Towards Increasing Motivation in Social E-learning," in *ICWL 2014*, vol. 8613, 2014, pp. 116–122.

[12] L. Shi and A. I. Cristea, "Motivational gamification strategies rooted in self-determination theory for social adaptive e-learning," in *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*, vol. 9684. Springer, Cham, 2016, pp. 294–300.

[13] E. L. Deci and R. M. Ryan, *Intrinsic Motivation and Self-Determination in Human Behavior*. Boston, MA: Springer US, 1985.

[14] M. Denden, A. Tlili, F. Essalmi, and M. Jemni, "Does personality affect students' perceived preferences for game elements in gamified learning environments?" *Proceedings - IEEE 18th International Conference on Advanced Learning Technologies, ICALT 2018*, no. August, pp. 111–115, 2018.

[15] O. P. John and S. Srivastava, "The Big Five trait taxonomy: History, measurement, and theoretical perspectives," *Handbook of personality: Theory and research*, vol. 2, no. 1999, pp. 102–138, 1999.

[16] J. Albuquerque, I. I. Bittencourt, J. A. Coelho, and A. P. Silva, "Does gender stereotype threat in gamified educational environments cause anxiety? An experimental study," *Computers and Education*, vol. 115, pp. 161–170, dec 2017.

[17] L. Z. Pedro, A. M. Z. Lopes, B. G. Prates, J. Vassileva, and S. Isotani, "Does gamification work for boys and girls?" *Proceedings of the 30th Annual ACM Symposium on Applied Computing - SAC '15*, pp. 214–219, 2015.

[18] I. Kotini and S. Tzelepi, "A Gamification-Based Framework for Developing Learning Activities of Computational Thinking," in *Gamification in Education and Business*. Cham: Springer International Publishing, 2015, pp. 219–252.

[19] A. C. T. Klock, I. Gasparini, and M. S. Pimenta, "5W2H Framework," in *Proceedings of the 15th Brazilian Symposium on Human Factors in Computer Systems - IHC '16*. New York, New York, USA: ACM Press, 2016, pp. 1–10.

[20] H. B. Mann and D. R. Whitney, "On a Test of Whether one of Two Random Variables is Stochastically Larger than the Other," *The Annals of Mathematical Statistics*, vol. 18, no. 1, pp. 50–60, jun 1947.

[21] S. Brin, R. Motwani, J. D. Ullman, and S. Tsur, "Dynamic itemset counting and implication rules for market basket data," *ACM SIGMOD Record*, vol. 26, no. 2, pp. 255–264, jun 1997.

[22] M. Tavakol and R. Dennick, "Making Sense of Cronbach's Alpha," *International Journal of Medical Education*, vol. 2, pp. 53–55, 2011.

[23] J. Manimaran and T. Velmurugan, "Analysing the quality of association rules by computing an interestingness measures," *Indian Journal of Science and Technology*, vol. 8, no. 15, pp. 1–12, 2015.

[24] P. L. Hardré, "SUCCESS for teaching assistant professional development," *The Journal of Applied Instructional Design*, vol. 2, no. 1, pp. 50–55, 2012.

[25] M. Csikszentmihalyi, *Flow: The Psychology of Optimal Experience*. Harper & Row, 1975.

[26] S. d. S. Borges, V. H. S. Durelli, H. M. Reis, and S. Isotani, "A systematic mapping on gamification applied to education," in *Proceedings of the 29th Annual ACM Symposium on Applied Computing - SAC '14*, no. Icmc, 2014, pp. 216–222.

[27] C. Dichev and D. Dicheva, "Gamifying education: what is known, what is believed and what remains uncertain: a critical review," p. 9, dec 2017.

[28] A. M. Toda, P. H. D. Valle, and S. Isotani, "The Dark Side of Gamification: An Overview of Negative Effects of Gamification in Education," in *Communications in Computer and Information Science*, vol. 832. Springer, Cham, mar 2018, pp. 143–156.

[29] Entertainment Software Association, "Essential Facts About the Computer and Video Games Industry," ESA, Tech. Rep., 2018.

ANNEX

L

VALIDATING THE EFFECTIVENESS OF DATA-DRIVEN GAMIFICATION RECOMMENDATIONS: AN EXPLORATORY STUDY

Validating the Effectiveness of Data-Driven Gamification Recommendations: An Exploratory Study

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Abstract. *Gamification design has benefited from data-driven approaches to creating strategies based on students' characteristics. However, these strategies need further validation to verify their effectiveness in e-learning environments. The exploratory study presented in this paper thus aims at verifying how data-driven gamified strategies are perceived by the students, i.e., the users of e-learning environments. In this study, we conducted a survey presenting 25 predefined strategies, based on a previous study, to students and analysed each strategy's perceived relevance, instanced in an e-learning environment. Our results show that students perceive Acknowledgement, Objective and Progression as important elements in a gamified e-learning environment. We also provide new insights about existing elements and design recommendations for domain specialists.*

1. Introduction

Gamification design[1] has become a topic of interest in recent studies in the field of computers in education. Many of these studies aim at providing guidelines on how to implement gamification properly, including in the education domain [Borges *et al*., 2014; Dichev & Dicheva, 2017]. However, literature states that gamification must be designed based on user characteristics, to ensure positive effects [Toda, Vale & Isotani, 2018; Santos, Bittencourt & Vassileva, 2018]. Prior works show also that gamification does not provide enough empirical evidence or enough data to attest its efficiency, which hinders the gamification adoption by domain specialists (teachers and instructors) [Toda *et al*., 2018b].

An alternative to tackling this issue is using the *data-driven approach* (*e.g.*, machine learning and data mining techniques) to analyse data provided by gamification/game-based systems, in order to provide empirical evidence on the gamification design [Meder, Plumbaum & Albayrak, 2017]. Although only a few studies have been conducted in this field, most of them are focused on the domain of business [Meder, Plumbaum & Albayrak, 2017]. Furthermore, these design strategies must be validated with users in order to provide their efficiency [Dichev, Dicheva and Irwin, 2018; Klock *et al*., 2018a].

[1] The process / method of creating gamified tasks

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This work thus aims at providing a validation process of the findings of data-driven gamification recommendations proposed by us in Toda *et al* (2019), where the authors used a data mining approach to provide gamification strategies based on user gender. We conducted a mixed epistemological research, through an inductive method in a semi-controlled environment [Gomes & Gomes, 2019]. The objective of this paper is to explore and explain how the data-driven gamification strategies would be perceived by real users. To this end, we created the following research question "*How do users perceive game elements implemented in e-learning environments, based on prior research on data-driven gamification recommendations?*". The contributions of this work are aligned with the field of Gamification in Education, providing validated recommendations that could be used in the development and improvement of gamified educational systems. These contributions are:

- Approach to validating data-driven gamification recommendations;
- Gamification recommendations that can be used by the domain specialists when designing e-learning environments;
- New insights into how users' perceptions are influenced by the game elements implemented in the environment.

2. Related Works

In the work of Klock *et al*., (2018b), the authors demonstrated how learning analytics could be used within a gamified e-learning environment to provide a better insight for teachers and instructors. Although relevant and providing many insights into the field, it does not focus/addresses how these analytics could impact on the gamification design process (*e.g.*, demonstrating which elements are more preferable by certain users).

Shi and Cristea (2016) explored how to approach gamification based on the theoretical underpinning of the Self-Determination Theory (SDT). The authors provided a novel way of concretely implementing SDT-rooted game elements in e-learning environments towards increasing student motivation. Their work also used a survey to validate the proposed gamification recommendations. However, unlike our current study, their work only focused on gamifying and improving social interaction features in e-learning environments.

Another work, conducted by Pedro & Isotani (2016), focused on identifying and understanding students' performance and gender differences towards *"gaming the system"* (behavior associated with cheating in learning environments). Their results indicate gender differences towards preferences of game elements in the environment. The female population had an overall lower performance, compared to males, which may be associated to the competition-driven elements (*e.g.* points, leaderboards and levels). The authors did not focus on giving or analysing gamification recommendations, but they inferred that female individuals might not like competitive environments.

Finally, the work of Toda *et al.* (2019) used Association Rule Mining (ARM) to identify relations between user gender and game elements in a given dataset. They provided 25 rules converted into gamification strategies. However, the authors did not validate those rules with real users, but stated that other demographic variables (*e.g.*, age group) could be used to provide more focused rules.

In addition, for the related works above, current research in gamification is concerned in understanding how the combination of game elements influence on the perception of students and users, when using gamified systems [Gárcia Iruela et al., 2019; Featherstone and Habgood, 2019].

3. Methods and Tools

To conduct this study, we analysed previous data-driven gamification strategies proposed in Toda *et al.* (2019). Following that work, with the aid of specialists in the field of gamification and e-learning environments, we created 25 mockups (see an example mockup in Figure 1) on how these strategies would be applied in a generic e-learning environment. Then, we created a survey, where the users would state the relevance of that gamification strategy in the context it was applied (that of a generic e-learning system). The survey was validated with 3 gamification specialists, before being sent to the users. The strategies can be seen on https://forms.gle/4FdMfLsE3zbjo9Lu9.

Fig 1. Example of a Mockup (related to Table 1 below, Id 10) that was presented to the users.

The relevance of the mockups was measured with non-polarised questions, in a non-biased way on a Likert scale [Likert, 1932] from 1 (Totally not relevant) to 5 (Totally relevant). Furthermore, each mockup was followed by a section where users could give open feedback and add comments, *e.g.*, "*I dislike Renovation*" or "*I really liked this layout*". We aimed at recruiting people with the same demographics - male and female, age group between 20 and 30 years, originally from Brazil (convenience sampling [Saunders, Lewis and Thornhill, 2009]). Henceforth, the recruitment process was conducted through email invitation. In total, we sent the survey to approximately 50 people.

All users would first need to agree that their data would be used for scientific purposes. The survey contained 29 questions: three questions were related to user demographics, one question on their perception of gender influence in game elements preference, and 25 questions directly about the mockups created. These mockup questions were divided into two groups, based on the gender (Male or Female). The users would

receive the groups of questions related to their assigned gender first, then the opposite gender on the second group of questions. We made the survey this way, in order to explore how user gender might influence their perception of the data-driven gamification strategies. The users did not know about these randomised groups until the survey was submitted. The data used in this paper can be found at https://bit.ly/2ZlqwGM. After collecting the data, we analysed it through descriptive statistics (i.*e.*, Mean and Standard Deviation) in the general group and per gender. Next, we analysed the comments of each mockup and summarised the results, for positive (*e.g.* "*I liked this element*" or "*I think this combination might work well*") and negative comments (e.g. "*I disliked this element*" or "*I don't think this works*").

4. Results

In total, 15 out of 50 (30%) of the invited people answered the survey, which constitutes our focus group. The distribution is almost similar between male (N=8) and female (N=7) populations. The minimum age is 18 and the maximum is 38 (Mean = 28.2, SD = 5.8). Concerning the education level, five students are at postgraduate level, six are at least at the undergraduate level, two at high school level, and one at technical and one at elementary school level. A summary of this data is presented in Figure 2.

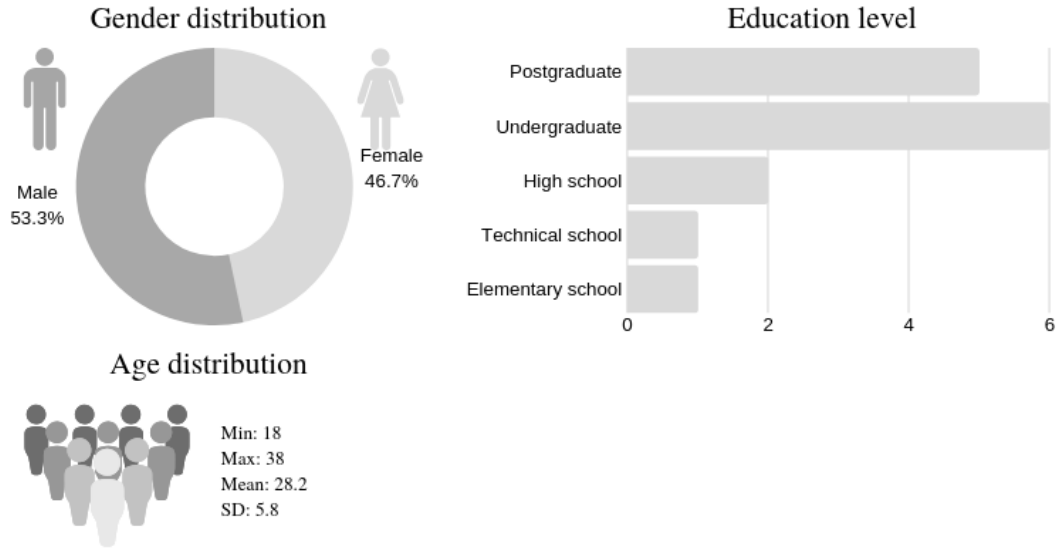

Figure 2: Summary of the demographics

Concerning the mockups, overall, the majority received a medium score from the users (respondents), with only one (Id 13, Mean = 2.7) achieving a score below the indifference point *i.e.*, 3, and two (Id 14 and 18, Mean = 4.2) above the relevance point *i.e.*, 4. A comparison of the overall results, and the results per genders can be seen in Table 1.

Table 1. Overall and gender analyses

Id	Elements in the mockup	Overall		Female		Male	
		Mean	SD	Mean	SD	Mean	SD
1	Progression-Data-Acknowledgement-Objective	3,8	1,1	3,8	1,5	3,8	0,5
2	Progression-Level-Acknowledgement-Objective	3,6	1,5	3,6	1,9	3,7	1,2

3	Progression-Acknowledgement-Objective	3,8	1,1	3,3	1,2	4,3	0,8
4	Level-Acknowledgement-Objective	3,6	1,1	3,8	1,3	3,4	1
5	Point-Acknowledgement-Objective	3,8	1,1	3,9	1,3	3,7	1,1
6	Progression-Puzzle-Objective	3,6	1	3,8	0,8	3,4	1,2
7	Novelty-Puzzle-Objective	3	1	3,3	1,2	2,8	0,9
8	Acknowledgement-Novelty-Objective	3	1,1	3	1	3	1,2
9	Acknowledgement-Choice-Objective	3,4	0,9	3,2	0,9	3,5	0,8
10	Data-Acknowledgement-Objective	3,2	1,2	3,2	1,5	3,3	0,9
11	Acknowledgement-Puzzle-Objective	3,6	1	3,3	1	3,9	1
12	Renovation-Progression-Choice-Objective	3,7	0,9	3,8	1,2	3,7	0,8
13	Progression-Social Pressure-Data-Objective	2,7	1,2	2,5	1,3	2,9	1,2
14	Progression-Puzzle-Acknowledgement-Objective	4,2	0,9	3,8	1	4,5	0,6
15	Level-Renovation-Progression-Objective	3,5	1,1	3,5	1,2	3,5	1,1
16	Point-Level-Puzzle-Objective	3,2	1,1	4	0,6	2,5	0,8
17	Progression-Level-Choice-Puzzle-Objective	3,4	0,9	3,6	1	3,2	0,9
18	Progression-Acknowledgement-Data-Objective	4,2	0,9	4	1,2	4,3	0,5
19	Progression-Level-Choice-Objective	3,6	0,9	3,8	1	3,4	0,8
20	Progression-Novelty-Data-Choice-Objective	3,2	1,2	3,3	1,4	3,2	1
21	Progression-Novelty-Acknowledgement-Choice-Objective	3,4	1,2	3,2	1,3	3,5	1,1
22	Progression-Level-Data-Choice-Objective	3,4	1	3,5	1,2	3,3	0,9
23	Progression-Novelty-Economy-Objective	3,7	1	3,5	1	3,9	1
24	Progression-Choice-Economy-Objective	3,6	1,2	3,3	1	3,8	1,3
25	Progression-Renovation-Novelty-Objective	3,2	1,2	3,2	1,1	3,2	1,3

As we can observe in Table 1, the perceived relevance of these combinations is relatively similar for most mockups, for both males and females. We highlighted the lowest (red) and highest (blue) in each column to identify which was the most preferred by each gender, based on the "Overall" mean. Concerning the mockups, the least preferred mockup (Id 13), contains Social pressure, which is the use of direct or indirect peer interaction as a way of motivating and engaging the users/players [Dignan, 2011]. In our mockup, we used a space that presented updates on other users' activities, as a way of creating a motivational pressure from their peers. As we can observe, this may not be the best way to present this element, since users didn't like it, as well as complained about it in their comments. Concerning the highest scoring strategies, we can observe that both genders preferred Progression, Acknowledgement and Objective elements.

Progression, according to Toda *et al.* (2019) refers to the visualisation of progress of the users within an environment. In our mockups, this concept was implemented using a *progress bar* that could measure the number of activities that were made by the user

(student). Acknowledgement is related to achievements/trophies, which are rewards given for specific actions within the environment, *e.g.*, 'the student finished 5 tasks in a row'. This was represented as trophies in our mockups. Objective is related to the learning goals, and was presented as 'missions'. These were original strategies found more relevant to males, in the work of Toda *et al.* (2019) and, in this work, were also found more relevant by the male individuals.

Concerning the comments, mockup 13 received the highest number of comments (9). Seven of these users states their "dislike" for the Social Pressure concept, stating that it may demotivate the final user by comparing them to other users. Only one person stated that they were pleased with the Social pressure concept. According to two comments, Social Pressure would be good for competitive users. Still concerning this mockup, the Data concept received two "dislikes" from the respondents. In our mockups, Data is presented as the visualisation of the user information as a number of correct and wrong tasks.

Mockups 12 and 23 received, respectively, a larger number of comments (8). Concerning mockup 12, most of the comments (5) stated that Choice was misplaced within this mockup, while four comments praised the use of Renovation. Choice was presented as a poll where the users (students) could choose their next assignment. Two comments stated that Choice should be something more meaningful, such as choosing the next subject. Renovation was presented through a re-do button, providing the student with the opportunity to perform the same task again. As for mockup 23, seven comments praised Economy while one said it did not like the element. Economy was presented in our mockup as virtual currency that could be spent in the system. Comments stated that Economy was an interesting element but the items that could be used as transactions should be more meaningful; there was also a statement about Economy being more relevant than Point. One comment also disliked Objective.

Mockups 2, 15 and 16 received seven comments each. For mockup 2, at least two users stated that Level and Progression should be one single element. In our mockups, Level was presented as a number that increased as the user gained points or completed a task. Two other comments stated that Level was indifferent to them and that the representation was rather confusing. One comment stated that they preferred Puzzle instead of Level in this mockup. On mockup 15, six comments stated they disliked Level; two suggested to group it with Progression. One comment disliked Renovation. As for mockup 16, five comments disliked the way the elements were presented while one comment stated that points should be used to buy things inside the system (change to Economy) and the other stated that Acknowledgement should be in place of Objective.

Mockups 1 and 5 received six comments each. On mockup 1, users stated that Data might not be that relevant, or should not be visible on the screen all the time. Other two comments implied that there were too many elements on the screen. One final comment suggested Data to be linked with Achievement. As for mockup 5, four comments stated they were displeased with Point, stating that this concept might be irrelevant when not being linked to Progression. Only one comment praised the use of Point in this mockup, stating that it should be great for continuous systems, where there was no progression towards the end.

Concerning mockups 4, 8, 20 and 24, each received five comments. For mockup 4, four users were displeased with Level, stating that it should be tied to Progression; one

user further stated their preference of Acknowledgement over Level. One person disliked Objective. Regarding mockup 8, four users did not like the way Novelty was presented. Novelty in our work was presented as a space presenting updates on the system activities and changes. One user stated that Novelty should contain more relevant information, and others said that Novelty was distracting. One user that praised Novelty said that the screen contained too much information. Mockup 20 received overall mixed comments, where users stated that Novelty and Choice could be shown in other sections of the system. Data received similar comments as before, since two comments affirmed that it could be presented through Progression or linked with Acknowledgement. Finally, in this subset of comments, mockup 24 also received some mixed reviews, since users stated that Choice should have another type of presentation. Besides, two users were pleased with the Economy.

When reaching the threshold of four comments per mockup (4, 6, 7, 9, 10, 17 and 25), most of these comments repeated what previous ones stated. Mockup 4 received mixed comments, where two stated their preference towards this mockup while the other two made suggestions on how to adequately represent Acknowledgement. Mockup 6 also received mixed comments, one stated that Puzzle should be linked to a type of reward, while one user liked the concept of Puzzle. In this work, we represented Puzzle as extra challenges where users could improve their scores and test their skills. Mockup 7 received similar feedback, where two users stated they did not like Novelty yet the other two were pleased. As for mockup 9, three comments praised the combination suggesting that Choice should be presented in another way, while one disliked the concept. Mockup 10 was disliked by four comments: users stated that Data should be linked to other elements and Acknowledgement should be tied to Progression. In mockup 17, two comments suggested that Level and Progression should be one single element or tied to Acknowledgement. One user stated they were displeased with Choice while other stated their preference towards it. As for mockup 25, the comments also presented mixed opinions: one disliked Choice; one disliked Objective; and two praised the combination and Renovation element.

Finally, under four comments, we have mockups 11, 14, 18, 19, 21 and 22. Mockup 11 and 14 received three praises from the users, where one of them stated it was the best combination. It is worth noting that Mockup 14 also achieved a high score overall. Mockup 18 received the same previous comments towards Data (also achieved the highest score along mockup 14). Mockup 19 had overall mixed reviews: one comment stated disliking Choice while the others suggested a link between Level and Acknowledgement. Mockup 21 received two positive comments: one suggested to change the way Choice was presented, and the other suggested to remove Objective. Finally, mockup 22 had two comments towards Data, that repeated what was stated before.

5. Discussions

Based on our results, we did not find significant differences in terms of the perception of the mockups, between the two genders, possibly also due to this being only a focus study, with few users. Moreover, interestingly, we can observe from Table 1 that the mockups received an almost similar score from both genders. This may occur because of the small sample size and thus may need further in-depth investigation. We can also observe that, overall, all the mockups received a similar relevance score near the average point (3).

When analysing the comments, we can observe that most of them referred to changing the way an element was presented or linking it to Acknowledgement / Progression for the sense of progress and meaningfulness. These analyses also allow us to infer some statements towards this data:

- Users perceive Level and Progression as the same thing, although in the concept defined by previous works Toda *et al.* (2019), Level is usually related to the users' skills while Progression is related to the system status. Nevertheless, it is understandable why most of the users stated their preference to link those two elements, since most games and gamified environments also tie levels and progression (e.g. Duolingo).
- Progression, Objective and Acknowledgement are usually well accepted when linked together, rewarding the users with medals/trophies/achievements whenever they complete a task in the e-learning environment.
- Choice and Data should be treated as part of the system and have a separate visualisation from the gamified user interface. Choice would be meaningful if linked to Acknowledgement (e.g., allowing the student to win different trophies based on their personal choices in the system). Data should be presented in a more subtle way (e.g., discreetly scattered through the mockup) and provide relevant information.
- Point is not relevant, according to all people who commented; i.e., it should not be used alone. Point should be linked to other elements to be more meaningful. Similar remarks were made about Data.
- Acknowledgement is the most praised element, which can be used to reward students as well as to make other elements more meaningful to them (such as Level and Objective).

Our work confirmed the data-driven strategies from prior work: Progression, Objective and Acknowledgement as the main elements and most accepted by the users. However, we did not find significant differences towards the genders.

As for the limitations of our work, a major one is the sample size (15) which is very low. When we asked the participants why they did not answer the survey, most of them stated that it was either too confusing or too long to complete (the average time to complete was 20 minutes). Due to this sample size, we cannot confirm using statistics if our results are significant. However, as it is known from the Human Computer Interaction literature that five users could be an acceptable sample to conduct a usability study[2], we believe that even though not achieving statistical significance, our results may be meaningful and able to provide insight from the users' perspective for designers and other domain specialists in the field.

6. Conclusions and Future Work

This work presented a validation of gamification recommendations for e-learning environments using a data-driven approach. This validation was conducted based on the students' perception of the game elements in mockups predefined based on prior research outcomes clustering gamification elements perceived as working well together. Through this study, we observed that the combination of elements do influence students' perception of the system. In this work we have shown faint differences between males

[2] https://www.nngroup.com/articles/how-many-test-users/

and females in terms of their perception of gamified elements and their pairing, such as female individuals preferring Progression element more than male individuals, while the second prefer Acknowledgement more than female individuals, which is the opposite from prior findings. However, we have found that Progression, Acknowledgement and Objective may be a suitable combination for both genders.

As future work, we intend to conduct a large-scale validation (with a larger sample size) on the relevance/acceptance of the combinations of the gamification concepts and game elements, in order to verify statistical differences towards their relevance to different genders. We also will be focusing on embedding these recommendations in a recommender system, to support the gamification design.

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References

Borges, S. de S., Durelli, V. H. S., Reis, H. M. and Isotani, S. (2014). A systematic mapping on gamification applied to education. In Proceedings of the 29th Annual ACM Symposium on Applied Computing - SAC ’14.

Dichev, C. and Dicheva, D. (2017) Gamifying education: what is known, what is believed and what remains uncertain: a critical review. International Journal of Educational Technology in Higher Education. Nature Publishing Group.

Dichev, C., Dicheva, D. and Irwin, K. (jul 2018). Gamification Driven Learning Analytics. International Conference on e-Learning. Academic Conferences International Limited.

Dignan, A. (2011). *Game Frame*. Free Press.

Featherstone, M. and Habgood, J. (1 jul 2019). UniCraft: Exploring the impact of asynchronous multiplayer game elements in gamification. International Journal of Human Computer Studies, v. 127, p. 150–168.

García Iruela, M., Fonseca, M. J., Hijón Neira, R. and Chambel, T. (25 jun 2019). Analysis of Gamification Elements. A Case Study in a Computer Science Course. In Artificial Intelligence in Education - AIED’19. . Springer, Cham.

Gomes, Alex Sandro; Gomes, Claudia Roberta Araújo. Classificação dos Tipos de Pesquisa em Informática na Educação. In: Jaques, Patrícia Augustin; Pimentel, Mariano; Siqueira; Sean; Bittencourt, Ig. (Org.) Metodologia de Pesquisa em Informática na Educação: Concepção da Pesquisa. Porto Alegre: SBC, 2019. (Série Metodologia de Pesquisa em Informática na Educação, v. 1) Available in: <https://metodologia.ceie-br.org/livro-1/>

Klock, A. C. T., Ogawa, A. N., Gasparini, I. and Pimenta, M. S. (2018). Does gamification matter? A systematic mapping about the evaluation of gamification in educational environments. In Proceedings of the 33rd Annual ACM Symposium on Applied Computing. ACM Press.

Klock, A. C. T., Ogawa, A. N., Gasparini, I. and Pimenta, M. S. (2018). Integration of learning analytics techniques and gamification: An experimental study. In Proceedings - IEEE 18th International Conference on Advanced Learning Technologies, ICALT 2018. IEEE.

Likert, R. A. (1932). A technique for the measurement of attitudes. *Archives of Psychology*, v. 140, n. 140, p. 44–53.

Meder, M., Plumbaum, T. and Albayrak, S. (2017). A Primer on Data-Driven Gamification Design. In Proceedings of the Data-Driven Gamification Design Workshop.

Pedro, L. and Isotani, S. (2016). Explorando o Impacto da Gamificação na Redução do Gaming the System em um Ambiente Virtual de Aprendizagem. Anais dos Workshops do Congresso Brasileiro de Informática na Educação, v. 5, n. August, p. 81–90.

Santos, W. Dos, Bittencourt, I. and Vassileva, J. (2018). Gamification Design to Tailor Gamified Educational Systems Based on Gamer Types. Anais dos Workshops do Congresso Brasileiro de Informática na Educação 2018, v. 7, n. 1, p. 42.

Saunders, M., Lewis, P. and Thornhill, A. (2009). *Research Methods for Business Students*. Prentice Hall.

Shi, L. and Cristea A.I. (2016). Motivational Gamification Strategies Rooted in Self-Determination Theory for Social Adaptive E-Learning. In Proceedings of the 13th International Conference on Intelligent Tutoring Systems, pp. 294-300. Springer, Cham.

Toda, A. M., Valle, P. H. D. D. and Isotani, S. (2018). The Dark Side of Gamification: An Overview of Negative Effects of Gamification in Education. In Communications in Computer and Information Science. Springer, Cham.

Toda, A. M., Do Carmo, R. M. C., Da Silva, A. P., Bittencourt, I. I. and Isotani, S. (2018). An approach for planning and deploying gamification concepts with social networks within educational contexts. International Journal of Information Management,

Toda, A. M., Oliveira, W., Shi, L., et al. (22 May 2019). Planning Gamification Strategies based on User Characteristics and DM: A Gender-based Case Study. In Proceedings of the Educational Data Mining 2019 conference.

ANNEX

M

FOR WHOM SHOULD WE GAMIFY? INSIGHTS ON THE USERS INTENTIONS AND CONTEXT TOWARDS GAMIFICATION IN EDUCATION

For whom should we gamify? Insights on the users' intentions and context towards gamification in education

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Abstract. *Gamification design in educational environments is not trivial and many variables need to be considered to achieve positive outcomes. Often, educators and designers do not know when the students' intentions on the use of gamified environments might influence their experience. Based on this premise, this paper describes an exploratory study on the users' intention to use gamification, focusing on its influence in the field of education. We conducted a survey study with participants (N=1.692) and analysed their answers using unsupervised data mining techniques. As a result, we obtained empirical evidence showing that demographic and contextual variables influence (positively and negatively) people's intention to use gamification. This evidence can support designers and educators better understand whether and when they should or should not gamify a learning environment.*

1. Introduction

The use of gamification in education has become a trend in the last decade [Deterding et al. 2011; Klock et al. 2020]. Recent literature studies indicate that gamification in the education domain has mixed results. From positive effects, such as increasing students' motivation and engagement, to negative outcomes, such as undesired behaviours and loss of motivation [Dichev and Dicheva 2017]. Many researcher have pointed out that these mixed effects are tied to the gamification design and context it is used [Dichev and Dicheva 2017; Klock et al. 2018; Toda et al. 2018; Pereira et al. 2020b].

The positive outcomes of gamification attracted educators' attention. Nevertheless, due to lack of knowledge, time, and resources, these educators are often discouraged to pursue a good design of gamification and apply it adequately together with their current pedagogical practices [An et al. 2020]. Furthermore, gamification is context-aware, which means that it is necessary to understand the contextual factors that permeate the users' routine to design gamification in their environment [Klock et al. 2020; Seaborn and Fels 2014]. According to Savard and Mizoguchi (2019), context can be either constructed of mental representations (internal context), or environment and circumstances (external). Internal context reflects personal characteristics that could

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impact the learning process, e.g., people experience and knowledge within a certain subject may influence their perception on understanding certain situations.

In previous studies, intentions on the use of gamification have been explored in different contexts and through different perceptions. Hamari and Koivisto (2015) analysed why people use health gamified applications and pointed out that usefulness, ease of use, enjoyment and playfulness are associated with a positive intention to use. In Rodrigues et al. (2016), the authors investigated the intention of use in e-banking context. According to their results, socialness leads to a positive intention of use, and the intention of use has positive influence in the users' perception. As we can observe, in both studies, the positive intention of use leads to positive attitudes towards a certain field.

To date, we did not find any studies that analysed the intention of use in the field of education, nor studies that analysed how previous knowledge and context influence towards that intention. This information is important to educators, to understand when and for whom they should gamify learning environments, since these design decisions might influence the students' perception when interacting with the learning environment [Klock et al. 2020].

Thus, we aim at providing insights to the existing body of knowledge on gamification by pursuing the following research question: *How users' demographics and contextual characteristics influence the positive intention towards gamification in education?* To answer this question, we conducted a survey study (N = 1.692 people) and analysed through a quantitative approach applying unsupervised data mining methods namely, Association rules (AR) and clustering, to find patterns within the dataset. AR analyses the relations between variables and clusters can provide an overall analysis that can be translated into patterns [Agrawal et al. 1993; MacQueen and Others 1967]. Through these algorithms we can understand how these variables might influence the *gamification* intention of use. Our findings include empirical evidence based on real data that can support the decision-making process of educators to know when and for whom to gamify learning environments. We also provide insights on how users' perceptions can be explored to further increase the acceptance of gamified systems.

2. Methods and tools

To conduct this research, we opted to follow an exploratory approach, since the objective is to verify the possible relations between the users' intentions and their context. Through this approach, we might provide new research questions to be explored in future studies. We conducted this approach using a survey, since it allows us to gather a considerable amount of user answers and is also a low-cost solution [Lazar et al. 2017]. We divided this approach in three steps, considering: data collection; analysis; and report.

For the data collection, we designed a questionnaire containing 12 questions that aimed to collect demographic (e.g., gender, age and country in which the respondent resides), and contextual variables (concerned with the users' background with gamification applications and games), as well as the intentions of using gamification in different fields (work environment, routine, health and education).

These intentions were chosen based on the popularity of gamification in those fields [Vargas-Enriquez et al. 2015]. The intention of using gamification questions followed a template of "*What would be your intention in using gamification in your [field]*" using a 5-point Likert scale [Likert 1932] from 1 "*Would not use at all"* (negative

intention) *to 5* "*Would definitely use*" (positive intention). We opted to analyse four different fields where gamification is usually applied and/or studied [Klock et al. 2020]. In this paper, our focus is on analysing the relations in the field of education. The recruitment of participants was carried out through Amazon Mechanical Turk (which has been considered a reliable platform for this kind of study [Bentley et al. 2020]) and social networks.

In the contextual variables, we consider the experience of the user by asking what they know about the concept of gamification, since the way an individual understands the environment (in this case, gamification) may influence the way they perceive the context [Savard and Mizoguchi 2019]. Concerning the concepts, we adopted three different concepts of gamification, an "*Other*" field, and one "*I don't know*" answer. For the concepts, we adopted as the main definition "*It is the use of game elements outside of a game*" [Deterding et al. 2011], another definition that is a partial concept "*It is a process to put games in non-gaming context*", and a misconception "*It is the process of making games*" [Deterding et al. 2011]. The "*Other*" concept could be defined by the participant. Concerning other contextual variables, we have also asked the participants if they usually play games, how many years they had contact with gamification, and which gamified applications they might have used. This questionnaire was created under supervision of 3 experts in survey design.

To analyse the data, we used AR and clusters since these methods are used to find patterns within a dataset and have been used in recent exploratory research concerned with gamification and data-driven methods [Palomino et al. 2019; Pereira et al. 2020a]. AR were used to find the relations between the intentions and demographic/contextual variables. These rules were measured and analysed based on their confidence, lift and support, following previous studies found in the literature [Palomino et al. 2019]. Clusters were used to identify general patterns; the number of clusters was defined by the knee point detection. Clustering can be used to analyse the intra- and inter-distance between cluster values marking the point of maximum curvature. To find this point, we used the K-means algorithm in a range of values from 2 to 12 (we assume 12 can be our upper boundary considering our data are on a Likert scale from 1 to 5) [Satopaa et al. 2011].

Moreover, with the goal of grouping similar individuals together into clusters, we use the popular unsupervised machine-learning algorithm *K-means*, which can be used to find subgroups with different profiles on Likert scale [1-5] data, as our *intention* variables. To choose the best number of clusters (k), we employed, as said, the knee point detection algorithm, which is a technique the can be used for automatic detection of the optimal k by analysing the maximum curvature [Satopaa et al. 2011] for each k point. According to Satopaa et al. [2011], the automatic k point detection algorithm is more appropriate than the common (and sometimes misleading) selection by visual inspection (ad-hoc analysis). As such, we fitted the *K-means* model with k values ranging from 2 to 12. Figure 1 shows k on the x axis, whist on the y axis we show the *distortion*, which represents groups' density (intra-cluster distance). As a result, the point with maximum curvature is five (dashed vertical line).

We also calculated the silhouette coefficient (which is the mean ratio of intra-cluster and nearest-cluster distance) using the same range for k (2-12). Despite it seeming that $k=2$ or $k=3$ (highest values for silhouette score) might be the best values, again, five was found as the optimal value using the knee point detection (dashed line in Figure 1b).

In addition, as explained before, we used on the *intention* variables a Likert scale [1-5], which likely would lead to one cluster for each Likert value and, hence, five subgroups of different profiles. Thus, we opted to use *k=5* based on our maximum curvature analysis and because it seems more appropriate for our data scale and, hence, gives us more nuances for analysis (five clusters instead of only two or three).

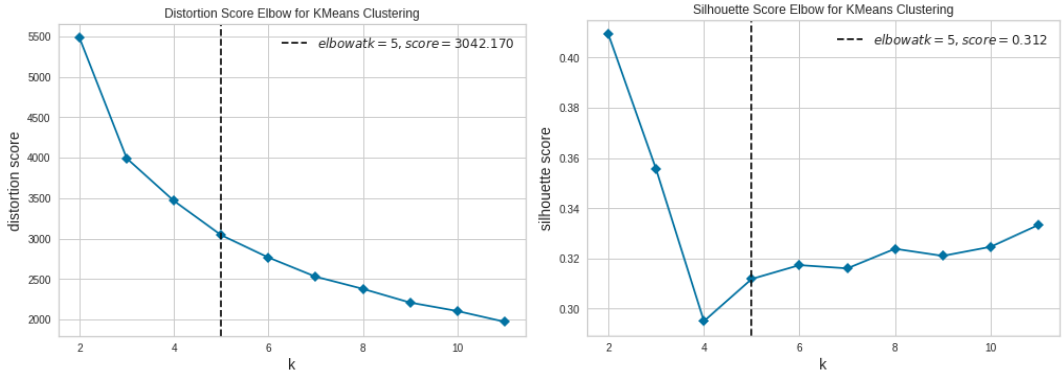

Figure 1. **(a) On left, distance score; (b) On right, sillhouette score**

Finally, to report the finding, we provided the complete data and steps of pre-processing used in this study, alongside descriptive statistics, association rules and clusters at the following link https://bit.ly/2EqVl8E .

4. Results and Discussions

4.1. Descriptive statistics

Initially, we collected 1.692 answers in 3 months (December 2019 – February 2020). Following, we pre-processed the data by: (a) arranging the ages in groups; (b) standardising the concepts of gamification; (c) arranging the countries by continent. In step (b), we identified 42 different concepts given by the users, that were analysed by two independent judges to verify if these concepts fall into one of the previous categories or "*Other*". The judges were both experts in the field of gamification, with more than 5 years of experience. In the initial analysis, using a Cohen's Kappa κ [Cohen 1960], the judges achieved a low agreement (κ = 0,3) then, a third judge was invited. Based on the third judge decision, 27 concepts were classified into one of the existing concepts and 15 were considered outliers, then removed. After removing the outliers, we analysed a total of 1.631 valid answers. Concerning the demographic variables, users reported 7 different genders, with the majority of individuals identifying as either Female (N = 838 | 51,4%) or Male (N = 778 | 47,7%), followed by Prefer not to say (N = 8 | 0,5%), Genderqueer (N = 1), and Non-binary (N = 6). The average age of our sample is 33,5 years (SD[1] = 10,5), minimum age being 14 and maximum being 75. For the countries, the majority (66,5%) were from North America. In cluster analysis, genders that were not Female nor Male were considered as NaN due to the low sample that impacted significantly on the cluster formation (less than 1%). In the same way, both Africa and Oceania were also removed for cluster analysis, due the sample being less than 1% total.

[1] Standard deviation

As for the contextual variables, most (N = 1410 | 86,4%) of our sample usually play games, while a few (N = 221 | 13,6%) stated they do not. Considering the concepts of gamification, few respondents (N = 248 | 15,2%) assumed they did not know what the definition was, while 226 (13,9%) respondents stated that gamification is the process of making games (misconception). Following, 391 (24%) respondents believe in the partial definition (process of putting games in non-gaming contexts) and a majority (N = 766, 47%) answered with the correct definition. Thus, **in general, we can observe that most of our respondents do not know the correct definition.** When asked about previous contact with gamification, we found a duality between their knowledge definition and usage, since 740 (45,4%) respondents stated that they did not have a previous contact with gamification, while 772 (47,3%) stated they had, and 119 (7,3%) affirmed they might have had contact. In other words, **this led us to believe that people that know the concept of gamification might not know how to recognise a gamified application, reinforcing the previous finding**. We had added an optional question that aimed to established which gamified applications these respondents might have used and the majority (approx. 321 entries) answered Duolingo, an educational platform, followed by TripAdvisor, a touristic guide (approx. 104 entries). Finally, concerning their experience with gamification (in years), the average is 4 years (SD = 4,1), minimum being 0 and maximum 30 years. Concerning the experience, **the concept was coined in 2011 but studies have reported that gamification is influenced by past events and practices that go decades before 2011 [Nelson 2012].**

Finally, considering the intention of use, we observed that *education* (ED) led to a higher intention of use (63,5%, when summing scales 4 and 5 that are tied to positive intention). In contrast, *work environment* (WE) translated into the higher negative intention to use (25,9%, when summing scales 1 and 2). A summary of these findings can be seen in Table 1.

Table 1. Intention of use. DR = Daily Routine; WE = Work Environment; ED = Education; HE = Health

	Intention (Scale | Proportion)									
Field	**1**	**%**	**2**	**%**	**3**	**%**	**4**	**%**	**5**	**%**
DR	157	9,3	201	11,9	**459**	**27,1**	**501**	**29,6**	374	22,1
WE	**224**	**13,2**	**215**	**12,7**	406	24	472	27,9	375	22,2
ED	145	8,6	148	8,7	325	19,2	489	28,9	**585**	**34,6**
HE	196	11,6	177	10,5	379	22,4	466	27,5	474	28

4.2. Association Rules and Clusters

To mine the AR, we used the R package *arules* [Hahsler et al. 2007]. Using a minimum support and confidence of 0,1 we found 723 rules: maximum support of 0,54 – rule 243 (**when the user is from the United States, they usually play games**); maximum confidence of 0,96 – rule 491 (**when the user gender is male, and they have positive intention in using gamification in daily routine, they usually play games**); and maximum lift of 3,78 – rule 610 (**when the user has a maximum intention to use gamification in their work environment, health and education, they also have maximum intention to use gamification in their daily routine**).

Concerned with the intention to use in education, we found 239 rules. Considering the positive intention (Likert scale 4 or 5), support (> 0,1), confidence (> 0,8) and lift (>1,3) we can summarise the number of rules to 16 (Rules 608, 254, 617, 621, 263, 629, 633, 296, 626, 273, 642, 309, 306, 650, 23 and 276). Through these rules, we can find contextual variables linked to the intention to use in education, according to our data, **people who *usually play games*, had *previous contact with gamified applications* and had *previous knowledge on what gamification is* have a *positive intention* to use it in education** (Likert scale = 5). In fact, the positive intention of use in other fields also impact the intention to use in education.

Concerned with the neutral or negative intention, we also found 16 rules related to the neutral intention (Likert scale = 3), but none of these rules followed the previous values for confidence (>0,8) and lift (1,3). The information presented in these rules is that **people who *usually play games* but *did not have previous contact with gamification* have *neutral intention* to use it in education**.

In the five clusters that were generated, we analysed the Mean and SD observing some profiles within our sample: Those who are indifferent (In white, Mean = 3) towards the use of gamification in education (Cluster 1); those who have positive intentions (In blue, Mean > 3) to use gamification in education (Clusters 2, 4 and 5); and those who have negative intentions (In red, Mean < 3) to use gamification in education (Cluster 3). The summary of the results can be seen in Table 2, and a summary of the Clusters can be seen on Figure 2.

Table 2. Cluster Analysis. DR = Daily Routine; ED = Education; HE = Health; WE = Work environment. In RED: Lowest value(s); In BLUE: Highest value(s).

Variables	Cluster Labels									
Intentions	C1	SD	C2	SD	C3	SD	C4	SD	C5	SD
DR	2,84	0,74	4,7	0,49	1,5	0,71	3,75	0,73	3,61	0,9
ED	3,06	0,85	4,84	0,42	1,6	0,8	4,19	0,75	4,24	0,67
HE	2,69	0,85	4,88	0,33	1,43	0,71	3,63	0,74	4,3	0,65
WE	2,87	0,8	4,7	0,51	1,28	0,52	4,11	0,5	2,37	0,73

In Cluster 1 (C1), indifferent intentions can be observed; we can also observe that people in this group tend to have a negative intention to use gamification in other fields. Most of these people usually play games, know what gamification is, but believe they did not have a previous contact with gamification. On demographics, gender distribution is almost equal, they are between 20 and 30 years and the majority lives in North America.

For the positive intentions, we can observe that Clusters 2 and 4 (C2 and C4) have similar analysis. Both clusters consider a positive intention to use gamification in other fields alongside education (Cluster 4 having a lesser positive intention in DR and HE). Considering their contexts, both clusters are composed of people who usually play games and know what gamification is; however Cluster 2 has more people that had previous contact with gamification; while Cluster 4 is almost balanced between people who had and did not have previous contact with gamification. For the demographics, both clusters are also remarkably similar in gender distribution, differing slightly in the age groups and

continent, where Cluster 4 has the smallest ratio of North Americans and highest rate of South Americans.

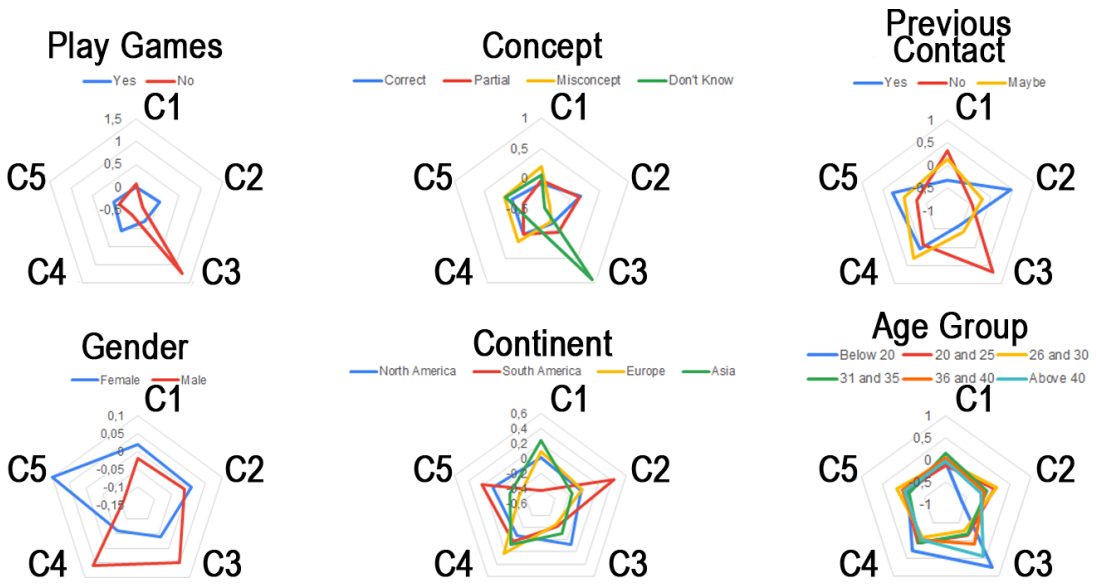

Figure 2. Clusters' variables distribution

Considering Cluster 5 (C5, also positive intention to use gamification in education), we can observe a negative intention towards WE. The context of this cluster is similar to Clusters 2 and 4, with people who usually play games, know what gamification is and had previous contact with gamification. Although, when analysing the demographics, we can observe this cluster has more female respondents than males. This cluster has also the slightest rate of people above 40 years. Geographical distribution is similar to the previous clusters.

Finally, considering the negative intentions towards education it is possible to observe that the whole Cluster 3 (C3) replicates this negative intention towards other fields. In other words, this Cluster is composed of people who do not want to use gamification at all, it is composed of people who usually play games, but do not know well what gamification is about (highest rate of people who assumed they do not know the concept of gamification or knew it partially). They also believe they have had no previous contact with gamification. Considering their demographics, we can observe an equal gender distribution, with people from all age groups and a majority of North Americans.

In summary, AR and clustering provided similar information towards the context of our sample, which means that previous contact with gamification, knowledge of the concept and habit of playing games do influence the *intention to use* in educational environments. This information can be used by teachers, instructors, and other educators to know when to gamify. Our demographic analysis did not present significant differences – except for Cluster 5, in which most of the sample is composed by female respondents. These results might have influenced users' response towards previous used applications, where most of the respondents (N > 300) used Duolingo as an example of a gamified application, which is an educational environment.

4.3. Discussion

This work provides insights on how the users' context and demographics influence their intention of use in gamification in education. Through this study, we add other variables (previous knowledge on gamification, previous use of gamified applications, and playing habits) that might be important to be considered when the designer and/or educator think about gamifying their learning environments, which is not often considered when designing gamification, but do impact on the users' experience [Hamari 2015; Rodrigues et al. 2016].

In future studies, researchers might ask the students about their intentions, knowledge and/or playing habits, to understand if that really influences and has a positive or negative impact on gamification. Another future research proposal would be identifying how culture (in this case, the country where the person resides in) is related to these factors as well, since culture is not a variable that is considered too often in the gamification empirical literature [Klock et al. 2020].

4.4. Limitations

During the design and implementation of this work we faced some limitations. Some of these limitations are concerned with the way we collected the users' intention of use, which could have been done through validated instruments, such as the Technology Acceptance Model [Davis 1989]. However, due its complexity and aiming at a broader public, we opted to use a single question self-assessing the intention of use through a Likert Scale, which is used to measure abstract ideas. Another limitation is the geographical distribution of our work, which might have been influenced by using Amazon Mechanical Turk; we could not control this variable without increasing the overall cost of this research. This could be enhanced or explored in future works.

5. Conclusion and Future Works

In this work, we focused on exploring and analysing the *influence of contextual variables over intention to use gamification in educational environments*. Through the data collected in our survey, we provided the following empirical contributions: (I) evidence that context (previous knowledge, habit of playing games, and contact with gamification) influence the intention to use; (II) and evidence that specific demographic characteristics do not play a major role in the intention to use.

We believe this analysis could be further explored in future works by increasing the number of respondents from different countries/continents, as well as different genders, to increase diversity. Finally, another work would be exploring these contextual variables within the design of gamification, as something to aid in the decision-making process by designers and other people who want to gamify a learning environment.

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References

Agrawal, R., Imieliński, T. and Swami, A. (1993). Mining association rules between sets of items in large databases. http://portal.acm.org/citation.cfm?doid=170035.170072, [accessed on Oct 22].

An, Y., Zhu, M., Bonk, C. J. and Lin, L. (6 jun 2020). Exploring instructors' perspectives, practices, and perceived support needs and barriers related to the gamification of MOOCs. *Journal of Computing in Higher Education*, p. 1–21.

Bentley, F., Neill, K. O., Quehl, K. and Lottridge, D. (21 apr 2020). Exploring the Quality , Efficiency , and Representative Nature of Responses Across Multiple Survey Panels. In *Proceedings of the 2020 CHI Conference on Human Factors in Computing Systems*. . ACM. https://dl.acm.org/doi/10.1145/3313831.3376671, [accessed on Jun 3].

Cohen, J. (1 apr 1960). A coefficient of agreement for nominal scales. *Educational and Psychological Measurement*, v. 20, n. 1, p. 37–46.

Davis, F. D. (sep 1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *MIS Quarterly*, v. 13, n. 3, p. 319.

Deterding, S., Sicart, M., Nacke, L., O'Hara, K. and Dixon, D. (2011). From Game Design Elements to Gamefulness: Defining "Gamification." *Proceedings of the 2011 annual conference extended abstracts on Human factors in computing systems - CHI EA '11*, p. 2425.

Dichev, C. and Dicheva, D. (20 dec 2017). Gamifying education: what is known, what is believed and what remains uncertain: a critical review. *International Journal of Educational Technology in Higher Education*. Nature Publishing Group. http://educationaltechnologyjournal.springeropen.com/articles/10.1186/s41239-017-0042-5, [accessed on Apr 17].

Hahsler, M., Grün, B. and Hornik, K. (2007). Introduction to arules--mining association rules and frequent item sets. *SIGKDD Explor*, v. 2, n. 4, p. 1–28.

Hamari, J. (2015). Why Do People Buy Virtual Goods ? Attitude towards Virtual Good Purchases versus Game Enjoyment.

Hamari, J. and Koivisto, J. (1 aug 2015). Why do people use gamification services? *International Journal of Information Management*, v. 35, n. 4, p. 419–431.

Klock, A. C. T., Gasparini, I., Pimenta, M. S. and Hamari, J. (13 jun 2020). Tailored gamification: A review of literature. *International Journal of Human-Computer Studies*, p. 102495.

Klock, A. C. T., Ogawa, A. N., Gasparini, I. and Pimenta, M. S. (2018). Does gamification matter? A systematic mapping about the evaluation of gamification in educational environments. In *Proceedings of the 33rd Annual ACM Symposium on Applied Computing*. . ACM Press. http://dl.acm.org/citation.cfm?doid=3167132.3167347, [accessed on Jan 8].

Lazar, J., Feng, J. H. and Hochheiser, H. (2017). *Research methods in human-computer interaction*. 2nd. ed. Morgan Kaufmann.

Likert, R. A. (1932). A technique for the measurement of attitudes. *Archives of Psychology*, v. 140, n. 140, p. 44–53.

MacQueen, J. and Others (1967). Some methods for classification and analysis of multivariate observations. In *Proceedings of the fifth Berkeley symposium on mathematical statistics and probability*.

Nelson, M. J. M. (2012). Soviet and American precursors to the gamification of work. *Proceeding of the 16th international academic MindTrek conference (pp. 23-26)*, p. 23–26.

Palomino, P. T., Toda, A., Oliveira, W., et al. (2019). Exploring Content Game Elements to Support Gamification Design in Educational Systems : Narrative and Storytelling. In *Proceedings of the SBIE 2019*.

Pereira, F. D., Oliveira, E. H. T., Oliveira, D. B. F., et al. (2020a). Using learning analytics in the Amazonas: understanding students' behaviour in introductory programming. *British Journal of Educational Technology*, p. bjet.12953.

Pereira, F. D., Toda, A., Oliveira, E. H., Cristea, A. I., Isotani, S., Laranjeira, D., Almeida, A., Mendonça, J. (2020b). Can We Use Gamification to Predict Students' Performance? A Case Study Supported by an Online Judge. In International Conference on Intelligent Tutoring Systems (pp. 259-269). Springer, Cham.

Rodrigues, L. F., Oliveira, A. and Costa, C. J. (1 oct 2016). Playing seriously - How gamification and social cues influence bank customers to use gamified e-business applications. *Computers in Human Behavior*, v. 63, p. 392–407.

Satopaa, V., Albrecht, J., Irwin, D. and Raghavan, B. (2011). Finding a" kneedle" in a haystack: Detecting knee points in system behavior. In *2011 31st international conference on distributed computing systems workshops*.

Savard, I. and Mizoguchi, R. (18 dec 2019). Context or culture: what is the difference? *Research and Practice in Technology Enhanced Learning*. SpringerOpen. https://telrp.springeropen.com/articles/10.1186/s41039-019-0112-5, [accessed on May 25].

Seaborn, K. and Fels, D. I. (2014). Gamification in Theory and Action: A Survey. *Internatoinal Journal of Human-Computer Studies*, v. 74, p. 14–31.

Toda, A. M., Valle, P. H. D. D. and Isotani, S. (20 mar 2018). The Dark Side of Gamification: An Overview of Negative Effects of Gamification in Education. In *Communications in Computer and Information Science*. . Springer, Cham. http://link.springer.com/10.1007/978-3-319-97934-2_9, [accessed on Oct 1].

Vargas-Enriquez, J., Garcia-Mundo, L., Genero, M. and Piattini, M. (sep 2015). A Systematic Mapping Study on Gamified Software Quality. *2015 7th International Conference on Games and Virtual Worlds for Serious Applications (VS-Games)*, p. 1–8.


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