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## A incorporação da metodologia ativa de gamificação nas unidades didáticas de futuros professores de matemática do Ensino Secundário

*The incorporation of the active gamification methodology in the didactic units of Preservice Secondary mathematics teachers*

### RESUMO

O objetivo deste estudo é analisar como futuros professores de matemática, participantes de um programa de mestrado em formação de professores de matemática do ensino secundário, incorporam a metodologia ativa de gamificação no planejamento, implementação e redesenho de unidades didáticas. Para isso, é realizada uma revisão de 98 dissertações de mestrado, onde os professores em formação avaliam a implementação de uma unidade didática e posteriormente propõem possíveis melhorias. Por um lado, observa-se que, embora a maioria deles não tenha considerado o uso de gamificação, há uma grande presença de jogos nas unidades didáticas analisadas. Por outro lado, para aqueles que adotaram a gamificação, observa-se que a justificativa mais comum para usar essa metodologia ativa é motivar os alunos.

**Palavras-chave:** Futuros professores de matemática do ensino secundário, Gamificação, Unidade didática, Dissertação de

### ABSTRACT

The objective of this study is to analyse how preservice mathematics teachers, who are participants in a master's program in secondary mathematics teacher training, incorporate the active gamification methodology in the design, implementation and redesign of didactic units. For this, a review of 98 master's thesis is carried out, where preservice teachers assess their implementation of a didactic unit and later propose possible improvements. On the one hand, it is observed that, even though most of them have not considered using gamification, there is a large presence of games in the analysed didactic units. On the other hand, for those who adopted gamification, it is observed that the most common justification for using this active methodology is to motivate students.

**Keywords:** Pre-service secondary mathematics teachers, Gamification, Didactic unit, Master's thesis.

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## INTRODUCTION

The term gamification, which was originated in the digital media industry in 2008 and popularized in 2010 (Deterding et al., 2011), goes beyond the field of digital media. As defined by Kapp (2012), gamification has gained popularity because it uses game mechanics, aesthetics, and game thinking to engage people, motivate actions, promote learning, and solve problems.

Since it is an active methodology, therefore student-centered, which is relatively recent (Piñero et al., 2022), there is still not much empirical evidence proving its effectiveness in learning, despite there are numerous studies on gamification in education. For instance, Araya et al. (2019), through the Conectalideas program, propose improving the math learning of fourth-grade students in Chile. The program uses gamification techniques to encourage the use of an online platform where students practice math exercises. The main result they obtained is a statistically significant improvement in math learning. Additionally, the program promoted the use of computers in learning math among the students, also it improved their self-concept by promoting effort and study as a means of enhancing intelligence. However, the program also showed negative results, such as increased anxiety about studying math and a decreased preference for teamwork.

In García Collantes' thesis (2020), statistical techniques are used to analyse the use of gamification techniques to develop mathematical skills. A positive and significant correlation is found between the level of gamification and skills, and the same occurs between gamification and motivation, demonstrating that gamification promotes the development of mathematical skills.

Another recent study is the case carried by Delgado Palacios et al. (2022), who use the tool *Kahoot!* to present an activity, as a summary of a topic, in a more playful way. As in the previous case, the use of technology in learning is promoted, although this is also the main drawback due to the difficulties these can entail. Overall, the students' evaluation of the experience is positive, but it is highlighted that the process had complications, probably because it was the first time that such activities were used.

Those results could be related to the conclusions of Illescas-Cárdenas et al. (2020), which explain that for students to have meaningful learning through game-related methodologies, those need to be developed properly. Given the teachers' lack of knowledge about these methodologies, it would be necessary to train teachers to implement them. These results are also supported by one of the recommendations from García Collantes' thesis (2020), which also suggests pedagogical training for teachers to apply gamification dynamics.

In Catalonia, teachers must complete a master's degree that qualifies them for teaching before they can work in secondary education. This master's program introduces them to the curriculum of the subject, the competencies to be developed in each course, and topics on innovation and research in Mathematics Education. Furthermore, preservice teachers are required to apply this knowledge in a document known as the Master's Thesis (TFM).

This study is based on the analysis of TFM conducted in a secondary education teacher training master's program specializing in mathematics for the 2021-2022 course. In these TFM, preservice teachers reflect on and analyse, according to suitability criteria, the implementation of didactic sequences (DS) previously designed and developed during



their practicum in their respective educational centres. From this reflection, they must propose improvements based on the analysed suitability criteria, which could include new activities, a new sequence, among other possible enhancements.

The objective of this study is to analyse how preservice secondary mathematics teachers, participants of a professional master's program, incorporated the active methodology of gamification in the design, implementation, and redesign of DS in their TFM. The research questions contemplated are: 1) Is gamification a methodology that preservice teachers consider when designing or redesigning a DS? 2) What gamification activities are proposed in the design or redesign of a DS? 3) What justifications do preservice teachers provide for incorporating gamification in their DSs?

## THEORETICAL FRAMEWORK

The use of games as a teaching method is advocated by Piñero et al. (2022), referencing that playing is a natural activity; therefore, the use of games in education makes it a universal activity. In the literature review conducted by Zabala-Vargas et al. (2020), it is concluded that there is a growing trend in publications about the use of game-based learning (GBL) in higher education, especially in the field of Mathematics Didactics. Additionally, studies such as those by Muñiz-Rodríguez et al. (2014) and Herreros and Sanz (2020) report, along with evidence from their own cases, an improvement in mathematics learning using this methodology.

The definition of GBL offered by Pho and Dinscore (2015) refers to the borrowing of certain game principles and their subsequent application to real-life scenarios to engage

users. It is also mentioned that GBL is not only about creating games for students; it also involves designing learning activities that can introduce concepts gradually and guide users towards a final goal.

Reviewing the literature on the subject, we find that the term gamification can cause some controversy and confusion (de Sousa et al., 2014). The confusion arises from cases such as the use of activities with a playful design where game aesthetics are used to capture attention in non-game contexts. This type of case often occurs with manipulative activities or the use of learning and knowledge technologies, where it is easy to fall into the misconception that the activity is a game, when it is simply a different way from the traditional one of presenting an activity.

Therefore, a quite precise definition of what gamification is the one given by Deterding et al. (2011), which refers to gamification as the use of game design elements in non-game contexts. They emphasize that it is not about playing full games, nor about using game-based technology or similar tools, and that the contexts are independent of the intentions of use and specific means of implementation. Thus, differentiating gamification from GBL. The difference between the two methodologies is that gamification is the application of game design techniques in non-playful contexts, while GBL is the use of games to promote learning. Additionally, gamification is typically an experience applied in the long term (Cornellà et al., 2020).

As it is described by Malvido (2019), to apply gamification there are a series of mechanisms and dynamics that activities should have integrated into depending on the strategies of gamification wanted to be implemented, as it is shown in Table 1.



Table 1 - Learning techniques based on game mechanics.

Points accumulation	Assigning a value to specific actions which accumulate as they are performed.
Level scaling	Defining levels that users must progress through.
Earning prizes or gifts	Rewards are given as objectives are achieved.
Rankings	Users move up or down in a ranking based on points or goals achieved.
Duels	Competitions among users to achieve prizes.
Missions or challenges	Accomplishing or overcoming a set challenge or objective, individually or as a team.

Source: adapted from Malvido (2019).

To analyse the TFM, Malvido's definition (2019) has been considered. This determines which didactic units have employed gamification during intervention and which have not.

According to the definitions of GBL and gamification, activities such as *Kahoot!*, for example, would be considered tools of GBL, since they are complete games. Although Ai Lin et al. (2018) do not make a clear distinction between gamification and game-based learning, they do define *Kahoot!* as a game-based learning platform.

## METHODOLOGY

The study's context is framed within the Professional Master's Program for Secondary Mathematics Teachers in Catalonia. It includes a Practicum course where teachers apply the knowledge gained by implementing a DS in basic education. Additionally, in the subject of Innovation and Introduction to Research in Mathematics Education, preservice teachers receive tools, such as the

Didactic Suitability Criteria of the Ontosemiotic Approach described in Breda et al. (2018), to develop and structure reflection (description, analysis, evaluation, and redesign) of the implemented DS. Specifically, it aims to develop competencies enabling preservice teachers to generate innovative and competitive learning proposals. The module also explores innovative teaching proposals on mathematics learning applied in various contexts. Finally, in the TFM course, students present a documented reflection about their practicum experience.

To answer the questions stated in the introduction, a review of all the TFM from the 2021-2022 course was conducted, with a total of 98 theses. There was a particular focus on sections discussing didactic sequencing, detailed activities performed during interventions, and descriptions of improvements made to the didactic sequence. Initially, identifying data such as the author's name for each TFM was recorded. Subsequently, an attempt was made to classify the TFMs according to the following five criteria:

1. It neither uses gamification nor GBL activities, nor does it propose them as a potential improvement for practical intervention.
2. It neither uses gamification nor GBL activities, but it proposes related activities as a potential improvement for practical intervention.
3. It uses GBL activities in practical intervention.
4. It occasionally uses gamification activities in practical intervention.
5. The entire intervention is based on gamification activities.

In addition to the classification, the names of the activities appearing in each TFM are noted and matched with the described

classification to also see which gamification activities are the most common. Some activities, due to their similarity, have been grouped according to whether they used the same type of game, such as *Kahoot!* and similar quiz-type activities, even if they covered different topics.

During the review, cases of TFM were found where conditions 3 and 4 were simultaneously met because they used activities from both methodologies. Therefore, a category 4.5 is created to account for cases where both conditions are met.

Finally, one pie chart and two bar charts are created as a summary of the types of gamification and GBL activities that appear in the DS.

## RESULTS AND DISCUSSION

From the classification done with the criteria described previously we obtain the first chart:

Figure 1 - TFM classification according to the use of gamification and GBL

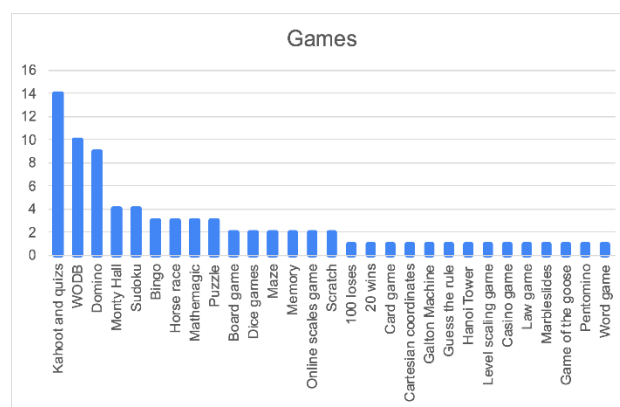


Source: the authors.

Out of the 98 Master's Theses analysed, 48 were found to use game-based activities, of which 9 DS also employed gamification exercises. In 2 TFM, gamification is only used occasionally, without referring to GBL, and in 1 TFM, the DS is entirely gamified. There are also 3 cases where neither gamification nor

GBL is used during the practical intervention, but improvements through their application are suggested. Finally, in 44 TFM, none of the described active methodologies are used, nor are any related potential improvements proposed. It is noteworthy that only 3 TFM specifically discuss the term gamification, one of which applies the methodology throughout the entire DS, another suggests it as a possible improvement, and the last one only mentions it in the conclusions without proposing any related activities.

Figure 2 - Chart of types of games from GBL that have appeared in DS



Source: the authors.

Regarding the TFM that have used GBL, as shown in Figure 2, *Kahoot!* and similar platforms have been the most used games, followed by Which One Doesn't Belong (WODB) games and various types of dominoes. In total, 30 different games and a total of 79 GBL activities were observed.

Although nearly half of the TFM have used games, this does not imply that gamification was employed in them, as gamification is actually derived from the sequence of activities and not from the use of games (Deterding et al., 2011). In fact, only one of the TFM has considered implementing the entire didactic unit using the gamification methodology.

Considering the TFM that have employed gamification, the completely gamified didactic unit was focused on a roleplay.

Toboso (2022) justifies the use of gamification and defines her didactic sequence with the following translated words:

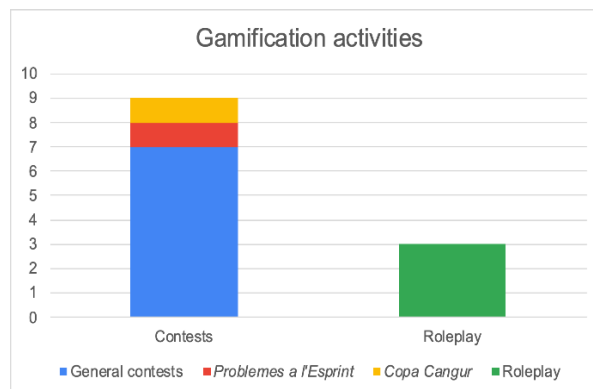
I have gamified the didactic unit as a motivational tool for the students. It consists of a Cyberpunk genre story, where the students belong to different groups of hackers aiming to take down a large corporation. Each week, I will publish a score that will depend on the work the students have done (since each activity is collected and evaluated).

It is important for them to know that all groups must reach a minimum score to succeed, so it not only promotes teamwork within the group but also collaboration with groups that have lower scores. Additionally, the group that leads each week will receive rewards within the story. Students can earn extra points (which will not count towards the subject's grade, but will count towards the group and hacker rankings) by doing creative activities, such as creating stories within the world, drawing their characters, taking mathematical photos, etc. (Toboso, 2022, p. 47)

Additionally, it justifies the use of gamification as a tool to motivate students while also aiming to promote both intra-group and inter-group work to achieve a common goal. The TFM also explains that, to organize the gamification, references were taken from other studies already conducted (Cornellà and Estebanell, 2018; Hernández Dorado, 2021; Muñoz, et al., 2019).

As shown in Figure 3, two other works include some roleplay exercises without necessarily mentioning directly that they are roleplays. The remaining eight TFM that have considered gamification contain activities focused on competition, whether individual or team-based, in some cases inspired by *Problemes a l'Esprint* and the *Copa Cangur*, both mathematical Catalan problem-solving competitions.

Figure 3 - Chart of types of gamification activities that have appeared in DS



Source: the authors.

In 7 out of the 11 TFM that use gamification occasionally, the authors justify its use to motivate students, make classes more dynamic, or encourage student engagement. In one of these 7 works, it is also mentioned that the aim is to promote teamwork and a sense of responsibility towards it. Out of the remaining TFM, one aims to promote the use of learning and knowledge technology tools, another author uses it as an extra resource in case there is a need to fill class time while also providing a general review of the DS, and finally, in two cases, no justification is given. Some examples of gamification activities that were encountered and translated are:

Thus, an attempt was made to promote individual involvement in cooperative work, responsibility, perseverance, and listening to both the teacher and classmates. As mentioned earlier, all activities were designed as group activities, but I would particularly like to mention the contest held at the end of my part of the unit, where groups that had been working together until then had to face this 'competition' to demonstrate their knowledge. (Rey, 2022, p. 19)

The group activity 'A Secret Message' also offers the possibility of using Scratch for its resolution, although there were no volunteers to do it during the sessions dedicated to these activities, needing to improvise a new one. (Santiño, 2022, p.



The other additional activity mentioned (...) is the extra session outlined in my DS, which reviews the entire unit through a group competition. Here, they had to solve a series of problems, and the points awarded for these problems varied depending on the successes and mistakes from their teammates and the time gone by. (Fernández, 2022, p. 5)

Out of the 3 TFM that have proposed to be improved by using GBL or gamification, Cáceres (2022) defines the Breakout Game as a gamification activity in which students must overcome a series of challenges or missions to unlock padlocks or a closed box. Often presented as a team-playing dynamic, a limited time frame is set to solve the challenges (de la Peña, 2021). This activity is also proposed to motivate students while verifying acquired concepts. In the last remaining 2 TFM, one suggests using competition as a method to engage students, and the other proposes activities considered as GBL.

## FINAL CONSIDERATIONS

In this study, the incorporation of gamification in 98 master's theses of preservice mathematics teachers was analysed. One conclusion drawn from the study is that gamification is not a widely used methodology among preservice teachers; instead, GBL is more common. Nevertheless, a significant number of preservice teachers still rely on more traditional methodologies. One possible explanation, according to Piñero et al. (2022), is that while GBL is increasingly recognized as a didactic methodology, it is still early to generalize about it. Furthermore, the misunderstanding surrounding gamification is reported by teachers as insecurity and lack of training to engage in such educational methodologies.

Another conclusion from the review of the theses is that competitiveness is one of the most utilized elements in both gamification and GBL. This could be because it is the easiest resource to apply, not exclusive to specific subjects, and does not require the same preparation as activities like roleplay.

Finally, it is observed that the most common justification for employing gamification is to motivate students, although this does not have to be the only justification (Martins et al., 2024; Martins and Tinti, 2022). Nevertheless, some preservice teachers do not provide any reason, and in no thesis is gamification documented with evidence of cases where benefits have been reported, either in mathematics learning or student motivation (Muñiz-Rodríguez et al., 2014; Herreros and Sanz, 2020).

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