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On the use of gamification tools for blended learning approaches in Thermodynamics courses

Gabriela Bracho[a], Pedro Martí-Aldaraví[b], Jorge García-Tíscar[c], Josep Gomez-Soriano[d]
[a] Universitat Politècnica de València (España, gbracho@mot.upv.es), [b] Universitat Politècnica de València (España, pedmar15@mot.upv.es), [c] Universitat Politècnica de València (España, jorgarti@mot.upv.es) and [d] Universitat Politècnica de València (España, jogoso1@mot.upv.es)

Abstract

During the last year 2020, education in European universities has suffered a challenging transformation from an established pedagogical model to a digital one. The face-to-face formal lectures have been replaced to on-line sessions and blended learning approaches. The courses related to the Thermodynamics subject of two Bachelor of Science Degrees (Mechanical Engineering and Automatic and Industrial Electronic Engineering) have been also adapted to the blended learning approach, in this case combining the use of screencast videos, interactive slides with comments, synchronous on-line lectures and tutorials, and virtual laboratories. This recent methodology has been demonstrated to be effective due to its flexibility and ubiquitous characteristics. However, one of the difficulties is tracking the engagement and the evolution of the students due to the reduced direct interaction between them and the instructors.

Among the technological tools that are used to benefit the learning process of students, gamification tools have been demonstrated to be effective and positive for academic performance. The aim of this study is to implement and evaluate the effectiveness of the gamification in the Thermodynamics courses where the proposed blended learning approach is used. One of the goals is to identify the specific competences acquired by the students after watching the audio-visual content (videos and slides). For this purpose, a Kahoot was played before starting the on-line lecture (synchronous), and according to the score, the instructor could recognize the level of understanding of the concepts. Based on the results, the instructor was able to focus more on the weaker learning objectives, capturing their attention during the session. At the end of the session the Kahoot was played again to recognize if the concepts were interiorized during the lesson. The results show that the use of this gamification tool achieved high levels of engagement and improved the attention and participation of the students.

Keywords: *Gamification tools, Online teaching, blended learning approach, Kahoot, engagement.*

Introduction

Teaching practice requires planning activities in order to satisfactorily establish the steps of the learning process (Landøy, 2020). In the last years, the education model has been suffering a challenging transformation from a traditional pedagogical method to a digital one. The blended learning approach is replacing the face-to-face formal activities, since this recent methodology has been demonstrated to be effective due to its flexibility and ubiquitous characteristics, allowing a more personalized system for instruction. Recent research shows that it is important to introduce virtual tools in the educational system. Moreover, this study concludes that the combination of online resources with face-to-face lessons is very valuable (Castro-Rodríguez, Y., & Lara-Verástegui, R., 2018). It combines the positive aspect of synchronous lessons (direct work and proximity) with the best of digital learning process (accessibility to information and speed of communication), enriching the education process and embracing more learning objectives (Días & Diniz, 2014). In this framework, a new methodology is proposed based on the blended learning approach (Graham, 2013) that involves the use of pre-recorded videos and interactive slides with synchronous on-line lectures and tutorials. This methodology is well aligned with the ability of the new generations in the use of Information Technology (IT). To promote the commitment of the students during the course, online gamification techniques were implemented to track and identify the competences acquired by the students after watching the audio-visual content. A real application of this methodology was employed in Thermodynamic courses of two different Engineering degrees at the Universitat Politècnica de València (UPV).

The content of this manuscript is divided into 5 sections. After this introduction, the second section summarizes the characteristics of blended education and gamification tools. Afterwards, the methodology is described, presenting the case of study and the survey. Later, the results of the Kahoots and surveys are explained, and finally the conclusions of the work.

Blended Learning and Gamification

Blended education combines face-to-face with online learning experience, under the hypothesis that both methods will complement each other, making use of their particular strengths (Yigit et al., 2014). The target is to use online technology not only as a complement, but to improve and transform the learning process. Studies have shown that this combination is helpful in increasing retention rates and motivation (Melton et al., 2009). However, some works have reported that the students could feel isolated because of a lack of interaction and communication with fellow learners and teachers and request tools to feel more integrated (Abdol Latif, 2009; Castro-Rodíguez & Lara-Verástegui, 2018; Días & Diniz, 2014). The advancement in technological infrastructure in universities together with the fact that most

students bring digital devices to the classroom has motivated new ways of interacting during the lessons (Wang and Tahir, 2020). The communication and interaction between the professor and the students can be done implementing new alternative techniques. One of these is gamification, which is the application of game-design elements and environments in non-game contexts (Licorish et al., 2018). Although this method is widely used in many fields, it is still emerging in education. (Bicen and Kocakoyun, 2017).

In contrast to traditional teaching methodologies where the acquisition of competences is promoted through cognitive processes of simple retention, gamification is a tool that, well designed and used, can have a positive impact on student learning (Dicheva et al., 2015). This is related with meaningful learning, where the ability of the student to use the knowledge learned is focused on solving problems and issues associated with didactic content (Mayer, 2002). Therefore, the main conditioning factors for meaningful learning are, on the one hand, that the learning material has a link with the previous knowledge of the students, and on the other, that they have a predisposition for learning (Moreira, 2012). With the gamification tools, these conditions tend to be fulfilled, since, in a friendly and fun context, the student adopts an active role where they must interact and cooperate to solve questions related to the content of the lesson (Zhao, 2019).

The tools available for gamification in the classroom and in on-line lectures allow to answer interactive questionnaires and short quizzes using any digital device, including the smartphone. Some of the applications developed for gamification are Quizizz, Socrative and Kahoot, among others. In this study, the Kahoot tool was chosen, which is a free online game-based platform that allows to create and configure educational multiple-choice assessments that are prepared to attend the necessities of the students as well as the requirements of the content of the subjects. With this tool the questionnaire is formed by questions and multiple-choice answers, that appear on the screen of the used device, where the student selects the answer and score points. The accumulated score can be seen on-line and can be shared with all the students, promoting interest, engagement, and a competitive environment.

Methodology

This study implements a blended approach combining synchronous on-line sessions, screencast videos prepared by the teaching staff, interactive slides with comments and virtual laboratories. Figure 1 shows the flowchart of the complete methodology that is divided in 4 main blocks: in the first one, the students should visualize an audio-visual material with a compilation of the main concepts of the didactic unit. After this, they attend the on-line lecture, where the instructor remarks the highlights of the content and solves exercises and applied questions. The third step focuses on the consolidation of the learned content, by means of a short assignment, and finally the evaluation. These blocks are represented by the rectangles in Figure 1. Following each block, a control activity is executed: two of them are

interactive tasks based on the Kahoot tool, the third one is the evaluation of the assignment with a feedback to the students (so they can learn from the correct answers and the mistakes), and the final mark after the exam. The overall target of these blocks and actions is to track the learning process from an early stage (for both the student and the instructor). For the sake of brevity, this document only focuses on the first two blocks (marked by the dashed line in the diagram).

Specifically, the first 2 activities try to recognize the competences acquired by the students after watching the videos prior to the lesson. Then, the initial Kahoot was played before starting the on-line lecture, and according to the score, the instructor could recognize the understanding level of the concepts by the students. Based on the results, the instructor was able to focus more on the notions that had lower scores, capturing their attention during the session. At the end of the on-line lecture, the Kahoot was played again to recognize if the concepts were consolidated during the lesson.

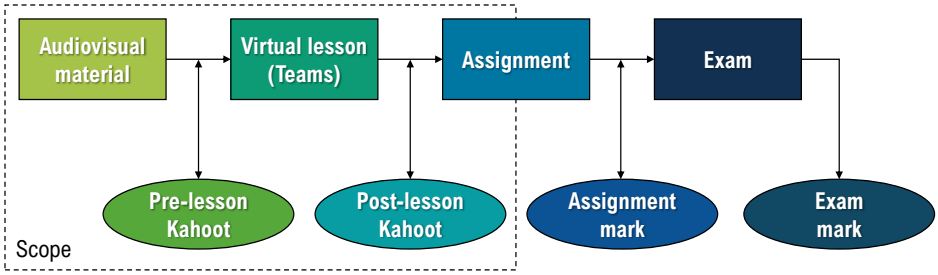

Fig. 1 Methodology of blended learning.

3.1. Case of application

The study was realized on two courses related to Thermodynamics: Thermal Engineering (2nd course of Mechanical Engineering Degree, named group A) and Thermodynamics (2nd Course of Automatic and Industrial Electronic Engineering Degree, named group B) at the Universitat Politècnica de València (UPV). The first group was formed by 41 students and the second one by 21. In both groups the same interactive Kahoot quiz was used. The average number of attendants (sum of face-to-face and connected on-line) per lesson is about 25 in group A and 14 people in group B.

3.2. Survey

Figure 2 shows an example of the structure of the Kahoot. Each item was a multiple-choice question with one right and three wrong answers. These two examples correspond to the didactic unit related to radiation heat transfer. The students have 60 seconds to answer each question. Usually, each Kahoot activity was formed by 4 different questions.

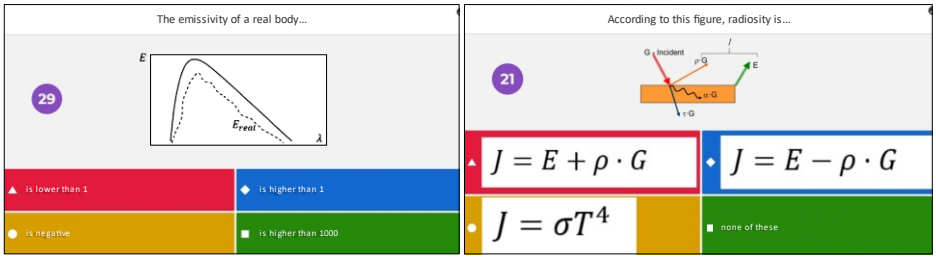

Fig. 2 Example of the Kahoot used in Thermodynamics.

The dynamics for playing the Kahoots consisted of sharing the link to all the students, and when all of them were connected to the platform, the time started. After the time runs out, the screen showed the score table and all the classmates congratulated the winners. After that, the instructor reviewed each question explaining the correct and wrong answers and providing suitable feedback.

Results

Tables 1 and 2 summarize the results obtained for the Kahoot before and after a lesson, for both Engineering degrees. The initial questionnaire reveals that more than half of the class have gained some knowledge from the initial block of the methodology, that contains the videos and audio-visual material.

Table 1. Results of Kahoot Before and After the Lesson (Group A).

Overall performance (before the lesson)		**Overall performance (after the lesson)**	
Total correct answers	63.89%	Total correct answers	93.75%
Total incorrect answers	36.11%	Total incorrect answers	6.25%
Average score (points)	2362.9 points	Average score (points)	4093.8 points

Nonetheless, there are still some contents of each didactic unit that should be remarked during the on-line session. Since the results of the activity appear automatically, the teaching staff can recognize this immediately and adapt in real-time the dynamic of the lecture. Moreover, the results of the second Kahoot (after the lesson) show an improvement in the right answers (from 64 to 93% in group A, and from 57 to 79 % in group B), being an indicator of the level of attention and learning during the lecture.

Table 2. Results of Kahoot before and After the Lesson (Group B).

Overall performance (before the lesson)	**Overall performance (after the lesson)**

Total correct answers	57.14%	Total correct answers	79.1%
Total incorrect answers	42.86%	Total incorrect answers	20.83%
Average score (points)	1708.71 points	Average score (points)	2918.67 points

As mentioned before, the implementation of gamification on blended learning is useful for the teaching staff since it allows the instructor to track the weak and strong points of the contents understood by the students. Also, it is a methodology that promotes the student motivation (proved below) since they feel involved in the learning process. And, last but not least, this is a tool for the self-assessment of the students themselves.

Nonetheless, in this case, 2 to 4 people still get a follow-up question incorrect. Two distinct factors could explain this. The first one, there has been some misunderstanding of the explanations given by the professors, easily solved by reviewing the class and notes after the live session or discussing the survey results with the professor or fellow students. The second one is the lack of interest in this type of activity (verified next), making the students not actively participating in the survey.

4.1. Student satisfaction survey

To assess the perception of the students about the use of gamification tools in the subjects, it was necessary to create a survey at the end of the course that collected the interest and the utility aspects of the students in relation to the use of the gamification. It was specified that the participation was voluntary and that their responses would be treated confidentially and for academic purposes. For a matter of time, it was only possible to apply it to the Group A. A total of 18 students agreed to participate in the survey, out of 41 who regularly attended class. The results of the survey are presented in Figure 3.

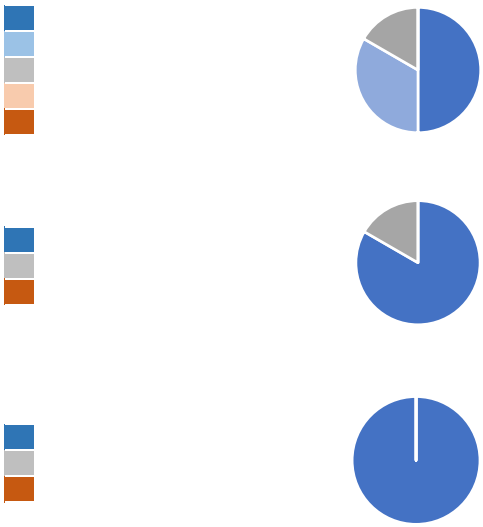

Fig.3 Results of the student's opinion about gamification.

The results from the first question show that the majority of the students find it useful or very useful (33,33% and 50% respectively), and the 16,67% were careless about the game.

According to the results of the second question, 83,33% of the students considers it is a fun activity, meanwhile the other 16.67% is indifferent to it (in agreement with the same percentage of the previous answer). The last question, asked if the score was improved the second time they played the game, after the lesson, and satisfactorily, the 100% answered that they improved the score. This reflects that the content related with items asked in the Kahoot were clarified and reinforced during the lesson.

The analysis of these results corroborates that the majority of the students value positively this type of activity, considering it useful and fun, which is an indicator of motivation. It somehow promotes the engagement during the lesson, since the students pay attention during the lesson, evidenced in the improvement of correct answers at the end of the session. Lastly, *even though Kahoot is synchronous by nature, a similar gamification approach could be implemented for asynchronous courses, in which the students would be offered timed questions, which would in turn be tallied into a common leaderboard.*

Conclusions

A gamification activity has been introduced in the Thermodynamics course of two different degrees at UPV as part of the teaching plan. The main goal of this activity was to increase the engagement of students, depleted by the reduced direct interaction. The results of this innovation show that:

- Pre-recorded videos are not enough for a complete acquisition of the specific competences by the students. Live sessions, even on-line, are necessary to clarify some concepts.
- Gamification tool is useful for weakness identification and adaptation of the live session to strengthen them.
- Gamification not only enhances the engagement of the students, but also improves the teaching-learning process itself.

The conclusions obtained serve to encourage the teaching staff to consider the use of innovative gamification tools so that students can participate more in the learning process. One limitation of the study was the sample size. Therefore, it is proposed to continue with this type of activities in successive curses in order to have more data available for the analysis. In the future, increasing the student's proactive role in the activity could be proposed as a way to further enhance engagement, for example, asking them to rate the questions of the survey or to propose new/improved questions for future students of the course.

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