Journal Title
XX(X):1–21

DOI: 10.1177/ToBeAssigned
www.sagepub.com/
SAGE

Evaluation of the impact of gamification on student's performance and engagement in manufacturing engineering courses

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Abstract

In engineering courses with a large number of students, fail and dropout rates are usually high even in courses that can be expected to be interesting to the students. Gamification tools have arisen as an interesting way to motivate the students for a real continuous assessment, increasing the student's attendance and performance. In this paper, a gamification approach based on a Kahoot tool, Moodle activities and commemorative badges is proposed within a manufacturing course. The designed activities let the students compete among them to get the maximum number of points, which will be converted into extra grades that are added to the final exam grade. The gamification experience has been proved to be highly positive according to students' and instructors' perceptions, and the average increase of pass rate and course attendance with respect to previous years have increased from 22% to 34% and from 38% to 66%, respectively.

Keywords

Engagement, Mechanical Engineering, Kahoot, Gamification

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Prepared using sagej.cls *[Version: 2017/01/17 v1.20]*

Introduction

Nowadays, lecturing is still the main tool for information transmission in engineering education. Although it is well-known that this methodology presents clear shortcomings such as lack of student engagement and being partially effective (19), it is a cost-effective way to instruct large number of students. When dealing with a low number of students, usually in the last year of engineering degrees or at master degrees, a large number of active learning approaches can be used in conjunction with lecturing such as inquire learning, just-in time learning, project-based learning, problem-based learning, case-based teaching, experiential learning and learning factories (1). However, in courses with a large number of students, most of these approaches may be unfeasible due to the excessive workload required by the instructor, and other alternatives should be found.

The main problem in lecturing consists in the misconception that the student works as a receiver when the instructor transmits the information through the lecturing. However, the student has to do something with the information (e.g., apply the information to a problem, discuss the information with others, etc.) in order to store the information in memory for long-term use. Furthermore, the process is based on the obvious premise that the *receiver* pays attention, which is not so obvious. As it is pointed out in (19), instructors' perception shows that students are unable to attend to lectures for more than 15 min at a time, which results in off-task behaviors such as chatting or texting. Only instructors with special charisma and abilities may drawn the students' attention using nice case studies, inquiring them with burning questions and so on. However, these abilities are not trained at the university level and it depends on the own ability and dedication of the instructor who has to struggle with classes, researches, mentoring and academic paperwork. Therefore, any improvement around lecturing to increase the motivation and the engagement of the students can be considered a useful tool for most of the instructors in higher education.

In the literature, student engagement is referred to "student's psychological investment and effort directed toward learning, understanding, or mastering the knowledge, skills, or crafts that academic work is intended to promote" (28). As stated by many authors, technology can facilitate engagement in many ways which could be difficult to achieve otherwise (43). In that sense, the use of learning management systems (LMS) with the available tools that they offer (assignment tools, quiz tools, debate and wikis tools, etc.) have been proved by researchers to have an impact on engagement and higher course grades (40). For instance, in (24) and (25), the authors found a strong correlation with the use of the LMS and students' performance. However, it should be remarked that student engagement may depend on the student-instructor interaction under the same LMS, as shown in (40).

Besides the use of LMS and the set of tools provided to encourage the continuous learning process and student's engagement, additional tools have been used by instructors for the same purpose. For instance, the use of "Khan-style" videos, where mathematical working drawn on a tablet screen is narrated in real-time, has

been also used as a engagement tool in higher education (41; 26). A good set of recommendations to produce short videos to engage students can be found in (26), where 6.9 million video watching sessions across four edX courses were analyzed.

Other engagement strategies that have been proved to be efficient in higher education are Game-Based Learning (GBL) and Gamification since individuals are more likely to stay involved in an activity if they find it entertaining and/or valuable (31; 42). Some authors even remark that GBL and Gamification in particular is considered one of the key and widely adopted teaching technologies in education in last decade (38). In fact, the European High Education Area (EHEA) that comprises the educational collaboration among 49 countries encourage the application of new digital technologies and innovative teaching methods to the higher education in order to promote a student-centered learning process (20). This transition is favored by current digital students' abilities since they are already digital natives, which facilitates the use of new educational methodologies if digital-related.

GBL is related to the development of games designed for educational purposes. In (37), seven types of GBL approaches were identified: memory games, simulation games, quiz games, puzzles, interactive games, strategy games and virtual reality games (Figure 1). Some of these games are ad hoc games that require an important investment, but others can be straightforward adjusted for any content, especially quiz, memory and puzzles games. From the types of GBL that can be found in the literature, quiz and puzzles type are the most commonly applied in education since can be easily adapted. An interesting review of GBL and recommendations for the design of games for a specific used in academics can be found in (36).

Figure 1. Types and examples of games for Game-Based Learning (GBL).

One of the most applied game-based platforms in higher education are related to Student Response Systems (SRS). These systems consist of a software where the teacher can propose questions and ask for feedback to the students, and it can be classified as quiz type games. Originally, the students had to use specific hardware, such as clickers, to be able to answer. That meant that the classroom had to be prepared beforehand. These hardware limitations as well as the acquisition cost implied that SRS were not frequently used. However, in the last decade, the proliferation of the use of smartphones has allowed to replace that hardware by the phones brought by the students. This is known as SRS based on BYOD (Bring Your Own Device). In the latest years, several SRS have been developed based on BYOD. As such, they include several

game design elements such as timers, points and competition between users in the functioning of their software. These SRS are known as Game-based Student Response Systems (GSRS) and can be recognized as GBL software. For instance, some of those GSRS commonly applied in education are *Kahoot*, *Socrative*, *Menterimeter* or *Quizizz*.

In the literature many different studies have been conducted using different GSRS (17; 5; 18). One of the most preferred GSRS tools adopted in academia is the Kahoot tool whose benefits and positive feedback from students have been studied in a wide amount of papers. The benefits that have been studied range from an analysis of the effects of game design elements of Kahoot such as the audio in the engagement of the students (21) or the impact on the students' motivation (9). A deep review of the effects of using Kahoot in higher education, and the most relevant papers published until then can be found in (22). (39) also reported the main advantages and disadvantages of using Kahoot after carrying out an educational experience with 100 students at pre-university colleges.

Focusing on applications of Kahoot, which is probably the most applied GSRS tool in teaching engineering lessons, we can find examples applied to a Bridge Engineering summer camp (11), Aeronautical Engineering (2), and Web Technologies courses (8). In a course about fluid mechanics (15), the group that worked on Kahoot proved to increase the passing rate in 12 points in comparison with the group where was no use. On the other hand, Kahoot can be used ever for gathering information from the students in a more entertaining way that using paper-based surveys, as proposed in (16).

On the other hand, besides GBL, a very interesting tool that instructors may use is the own gamification of the course. Gamification has been defined as "the use of game design elements in non-game contexts" (6). A task can be gamificated by adding a game-like layer during the design of that task, which is achieved adding concepts, mechanics and dynamics typically related with games and videogames (Figure 2), such as leaderboards, levels, rewards, time constraints, or even stories, quests and sidequests (12) . The main purpose of task gamification is engaging the user into completing that task, making it more funny and interesting. As stated in (4; 23), the gamification of the course motivates the student to participate since he receives an immediate feedback and perceives progress in his learning which encourages him to be interested in the subject, and it is an effective approach for formative assessment.

Many different educational experiences can be found related to gamification of course contents. In (10), the authors proposed and analyzed the gamification of the laboratories of a course in mechanical engineering by adding achievements and badges on the course website, which could be earned by participating in the proposed activities. A similar approach was followed in (3) in a MSc in Computing Engineering, and in (7), where the effect of extrinsic motivators (regarding the final grade) was highlighted. In a recent research (14), the use of leaderboards in some course activities to emphasize continuous performance and self-study was proved to have an impact on learning performance. All these experiences present game design elements

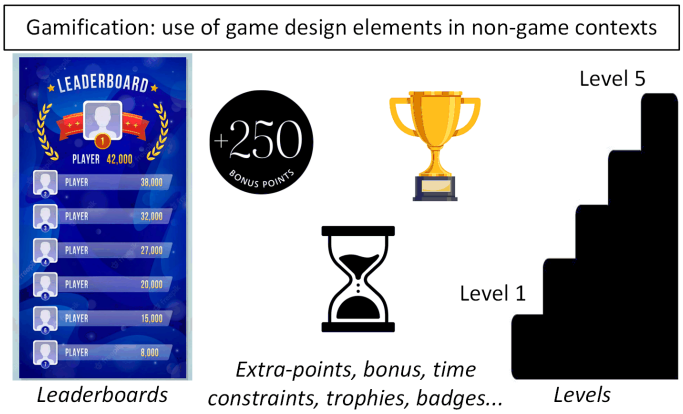

Figure 2. Common concepts added into course dynamics for gamification.

that encourage the engagement of the students on the activities to compete among them.

From the review presented above, an interesting approach to improve motivation and engagement in engineering education is a mix between the use of GSRS tools such as Kahoot together with a gamification of the learning process through game-based elements like leaderboards and awards along the contents of the course. In the present paper we propose the application of a gamificated continuous assessment in a Manufacturing Technologies course at Universitat Jaume I, Spain, in different engineering programmes. The gamification of the continuous assessment is implemented using Kahoot to engage the students in attending the classes and studying the contents of the theory lessons, as well as using a moodle-based platform to solve optional exercises. Successfully completing those tasks grants points to each student; a leaderboard that ranks the students depending on the acquired points is presented, and after finishing certain units, bonus points on their final grades are granted to the top students. Given that the subject has one of the lowest student performance in both degrees, obtaining bonus points is presupposed to be an additional source of motivation, which engages the students to keep studying the course during the semester.

The gamification experience is analyzed in detail through different key performance indicators (KPI) to evaluate the engagement and the performance of the students in comparison with previous years. Furthermore, the student's and instructor's perception about the gamification experience are studied through a survey. The experience has been proved to be highly positive with a significant impact on the ratio of students that take the exam in both first and second exam calls, and most of the students agree with the usefulness of the gamification approach that motivates them to keep working on the contents of the course in a weekly manner.

This paper is organized as follows. The first Section describes the implementation of the gamification experience and the course details where it is implemented. Then,

a specific Section is presented to describe the parameters that are used to evaluate the performance of the gamification experience. Later, we present the results obtained and their corresponding analysis. To conclude, a final Section is presented to show the main conclusions of the paper.

Description of the gamification experience

The course "ET/EM1029 - Manufacturing Technologies" is taught in the second semester of the third year of the Degree in Industrial Technology Engineering and in Mechanical Engineering at Universitat Jaume I, Spain. The teaching methodology of this course consists of three main parts: theory lessons, problem sessions and laboratory/shop floor sessions. Theory and problem sessions are taught almost every week, but there are only 5 sessions of laboratory and shop floor. The students take two "mid-terms" along the course, and there is a final exam. Mid-terms and laboratory activities define the "continuous assesment" grade, which is 40% of the final grade. The final exam counts 60% of the final grade. Currently, this course has an important rate of students that fail the exam, and the instructors' concern is the high drop rate along the course together with the low ratio of students that take the final exam.

The current gamification experience has been conducted in the second semester of the course 2020/2021. Despite the COVID-19, the classes at this institution were not moved to online, and the instructional classes were taught as usual but with the mandatory use of mask and social distance. The main goal of the experience is to increase the students' engagement along the course, and increase the number of students that take and pass the exam. The current and proposed additional gamification scheme of the course is shown in Figure 3. As it can be seen, the idea is to motivate the student's attendance to class through a group of activities based on Kahoot and Moodle platform. These group of activities let the students to gain points and transform them into an extra grade (up to +1 point).

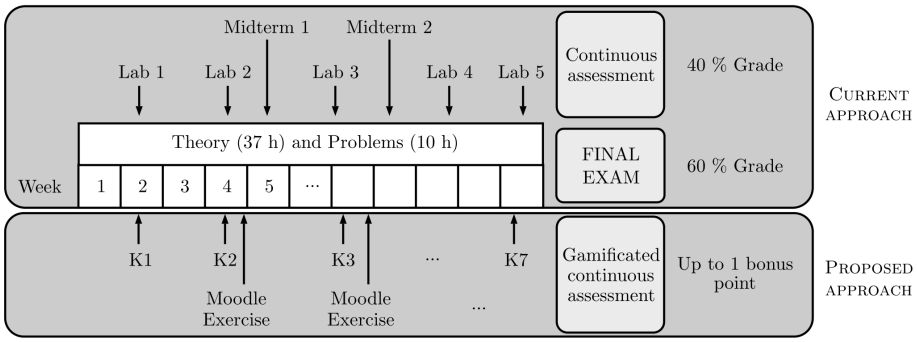

Figure 3. Proposed approach. The structure of the course is kept as previous years (theory and problems, laboratory/shopfloor and midterms) but it is included an additional gamificated continuous assessment based on Kahoot and Moodle exercises.

Since this course has one of the lowest student performances of both degrees, these bonus points are welcomed by the students and it is expected that they will keep them engaged to the contents of the course. Students can obtain points by participating and correctly answering questions in Kahoots held during the theory lessons, and by solving complex problems on-line using the Moodle platform. The points are given as a function of the relative performance among students, so they compete against their peers to achieve the top places in the leaderboard. The highest-scoring students receive additional bonus points in the final grade of the course. The experience is independent for each degree, therefore, there are two leaderboards, one for each corresponding degree.

Please, note that the structure of the course is kept as previous years but we add an additional gamificated continuous assessment based on Kahoot and Moodle exercises that can provide up to one extra point in the final grade. Therefore, the theory sessions, problems, laboratory/shopfloor activities and midterms are similar to previous years, and we keep the same continuous assessment based on laboratories and midterms (40%) and the final exam (60%). Under this scheme, we add a gamificated continuous assessment with voluntary activities in class (Kahoot) and at home (via Moodle platform) to motivate and engage the students. The characteristics of these tests/problems are explained below.

Kahoot tests

Kahoot tests were implemented to favor the attendance to the theory lessons, as in previous years the number of attendees notably decreased throughout the semester. They were also implemented to encourage reviewing the concepts explained in previous theory lessons, so the students would keep studying the course and not leave it until the final exam. Furthermore, these tests were also implemented to make the class more interactive and to avoid long lecture sessions where students tend to disengage. Therefore, the tests were conducted during the theory lessons after a thematic unit or group of units are finished and when the lecturer perceives that the students are losing the attention. Each test consists on 6-8 questions, some of them multiple-choice questions, with randomly-mixed available responses. Figure 4 shows an example of a test related to machining.

Kahoot generates points depending on the number of correctly answered questions and the total time used to answer each question, which was set to 40-60 seconds. After each test, Kahoot generates data with all the results and obtained points of each player, which can be exported in several formats, such as Excel. After each test is completed, we add the obtained points to the grand total for each player, and display the updated leaderboards in the Moodle platform where all the information of the course is posted.

Moodle exercises

Besides acquiring points with the Kahoot tests, students can also increase their scores with optional exercises after a global thematic unit is completed. These exercises are proposed in the Moodle platform used by the university and they are parameterized

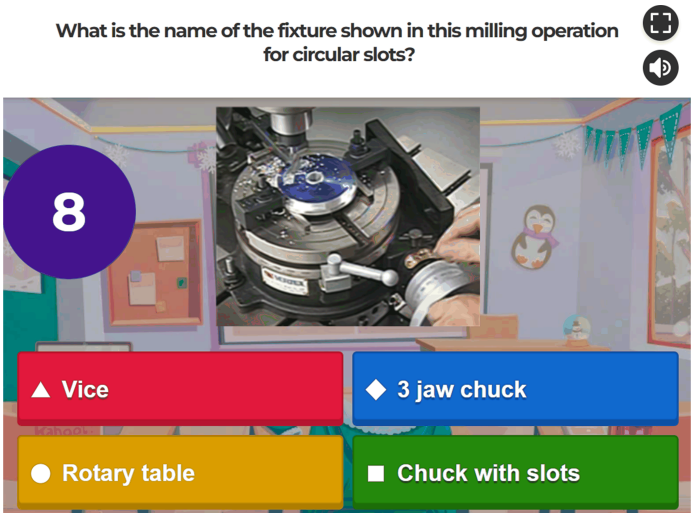

Figure 4. Example of Kahoot test related to machining.

and randomly selected from a predetermined set of exercises to avoid cheating. The exercise can only be solved within a 3-4 hour span in a fixed day, and it must be solved within 1 hour since the formulation of the problem is presented in the screen. Once the 3-4 hour span finishes, the problems are evaluated automatically, the obtained grade is converted into points and added to each student's score. Figure 5 shows an example of a Moodle exercise related to the topic bulk forming (rolling process).

The point conversion is a key issue that must be calculated correctly to avoid discouraging students that pay attention to the course but they performance at Kahoot tests is weak. The point conversion is presented in this manner: a grade of 10/10 in the optional exercise grants the same amount of points as the maximum number of points earned in the Kahoot tests by the best student in the same global thematic unit. Lower grades grant a proportionally lower amount of points. The conversion formula is shown here:

$$Exercise\ Points = \left(\sum^{units} Kahoot\ Points \right)_{leader} \cdot \frac{Exercise\ Grade}{10} \quad (1)$$

Rewards

In this experience, two types of rewards are provided: extra points to be added to the final grade, and commemorative badges. The extra points are earned by the students after each global thematic unit and at the end of the course. For each global thematic unit, a leaderboard is created based on the Kahoot results and the Moodle exercises. For this activity, the top 10% of the students receive 0.25 bonus points on their final grade. Furthermore, the best student's performance at each global unit receives a

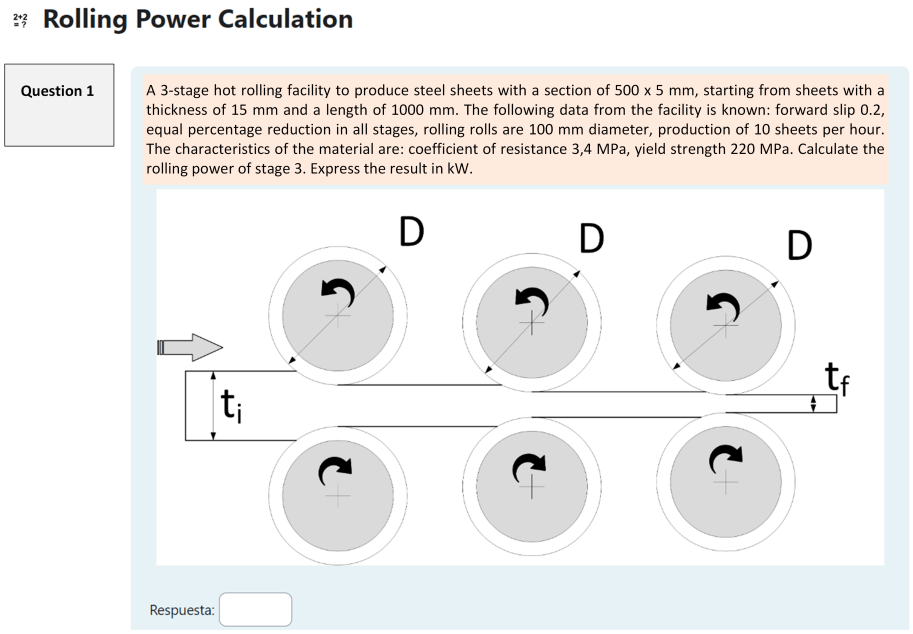

Figure 5. Example of Moodle test related to bulk forming.

commemorative virtual badge through Moodle platform which is expected to be an additional motivation factor to the students. The badges created are related to metrology, casting processes, bulk deformation processes and machining processes and they are shown in Figure 6. Figure 7 shows the scheme to calculate the extra bonus points.

Figure 6. Commemorative badges to acknowledge the best performance at the global units of metrology, casting processes, bulk deformation processes and machining processes.

Additionally to this 0.25 bonus points per each global thematic unit, we update a general Kahoot leaderboard with all the Kahoot scores along the course. We do not add here the Moodle exercises in order to give more importance to the Kahoot activity and the attendance to class. At the end of the course, the top 40% of the students received some extra points to be added to the final grade. In this case, the top 7% received an extra 1 bonus point on their final grade, the following 7% received 0.8 bonus points, the next 7% obtained 0.6 bonus points, and so on. Figure 8 shows the

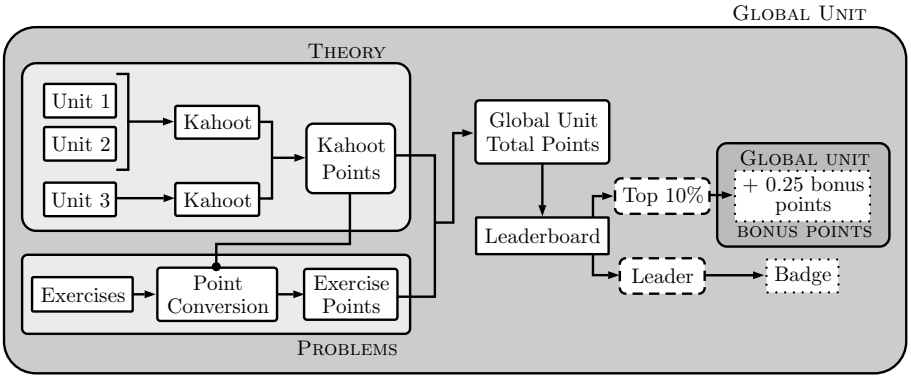

Figure 7. Total points calculation for a global unit.

scheme to calculate the extra bonus points.

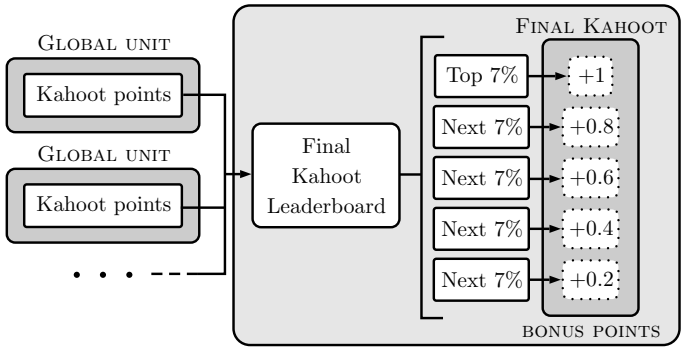

Figure 8. Final Kahoot leaderboard calculations.

The bonus points obtained in each of the three global thematic units and the final Kahoot leaderboard are accumulative up to a maximum of 1 bonus point on the final grade. Note that these bonus points can only be applied to the final grade if the original final grade is above 4/10.

On the other hand, the badges are bestowed on the best student for each global thematic unit, so a badge to show the best student's performance on metrology, casting processes, bulk deformation processes and machining processes is created as shown in Figure 6.

Evaluating the gamification experience

The objective of this section is to evaluate the impact of the gamification of the continuous assessment on the student's performance and engagement in this course.

Several key performance indicators (KPI) of the course are defined and compared with respect to previous years. The KPI defined are as follows:

1. KPI for engagement analysis:
    - Student's attendance to class in the last third of the course.
    - Number of visualizations of problem collections at Google Sites. To obtain this KPI, the instructors have uploaded a collection of solved problems related to metrology, bulk plastic deformation and machining in Google Sites, which can be only visualized online (Figure 9 shows the problem collections). The students use these collections to prepare the exam and thus, the number of visualizations of each collection provided by Google Sites is of great interest to analyze the engagement of the students.
2. KPI for performance analysis:
    - Number of students that have taken the final exam with respect to the total number of student enrolled in the course.
    - Number of students that have passed that exam on the first and second exam calls with respect to the number of students that have taken the exam.

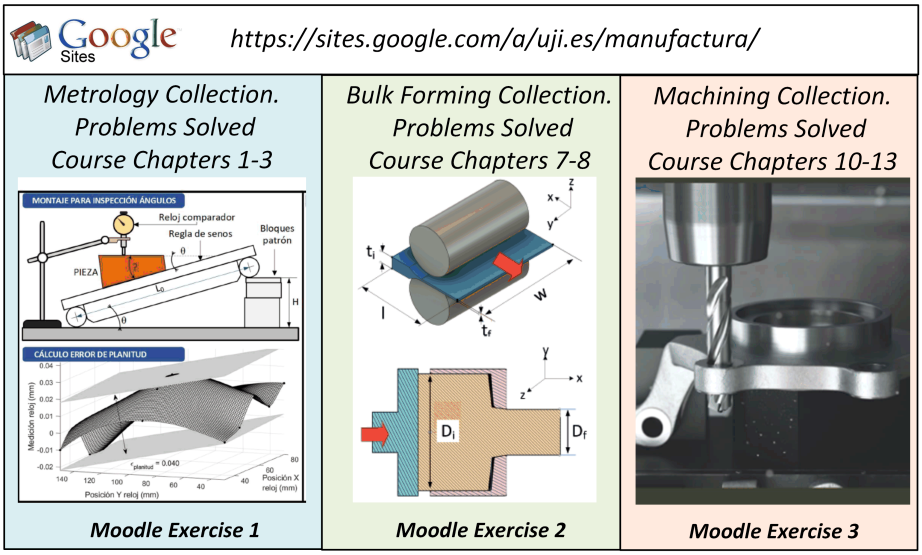

Figure 9. Google Site address and problem collections available to students.

Note that all the KPI refer to the current course and the courses 2013-2016, since the instructor from 2017 to 2020 was different for the theory lessons and we want to avoid any possible bias. The exception is the KPI about the number of visualizations of problem collections at Google Sites, where the courses 2018-2021 were used since the Google Sites was available from that moment onwards.

On the other hand, we have asked the students about this gamification experience by means of a survey. The questions we asked are shown below:

1. Did you attend the theory lessons more frequently due to the Kahoot tests?
2. Did you review more frequently the theory lessons thanks to the Kahoot tests?
3. Do you consider that we should keep using Kahoot tests next year?
4. Do you consider that we should keep proposing the Moodle exercises next year?
5. In what way did the Kahoot tests and Moodle exercises engage you and encourage you to keep studying the course?
6. Do you consider that the amount of bonus points obtained with the Kahoot tests was appropriate?
7. Do you consider that the amount of bonus points obtained with the Moodle exercises was appropriate?
8. Do you consider that the amount of time given to solve the questions in the Kahoot tests was appropriate?
9. Is there any commentary that you would like to tell us?

Furthermore, we have asked the instructors that have implemented this gamificated continuous assessment system about their opinions and comments about the experience. All these analysis and commentaries are discussed in detail below.

Results and discussion

Engagement and performance indicators

The attendance to the course during the last years can be evaluated using the number of participants at the students' evaluation of the course conducted by the institution around the last third of the course. Since the instructor was different from courses 2017-2020, those years are not included here. Figure 10 shows the evolution of this KPI. As it can be noticed, the main purpose of the gamification experience was achieved since a higher number of students kept attending the classes. An increase of 24 percentage points was obtained with respect of the average percentage attendance from previous years.

Furthermore, we can also observe the engagement of the students with the course by analyzing the attendance to each Kahoot and thus, to the theory lessons. As it can be seen in Figure 11, the attendance started to decrease from the half of the semester onwards, and it is minimum at the end of the course due to the proximity of final exams and the deadlines of reports and other activities that may be requested by other instructors. This is the normal students' behaviour in our institution, at least in engineering courses, but the proposed gamification approach has cushioned this phenomenon as we compare with previous years (Figure 11). The results from the Mechanical Engineering Degree seems to present a higher number of disengagement, but in both degrees the number of students that attend to the class at the end of course is still high in comparison with previous years.

Another KPI to analyze the improvement of the engagement through the gamification experience is the number of visualizations of the problem collections available at Google Sites. These problem collections were available online since 2018,

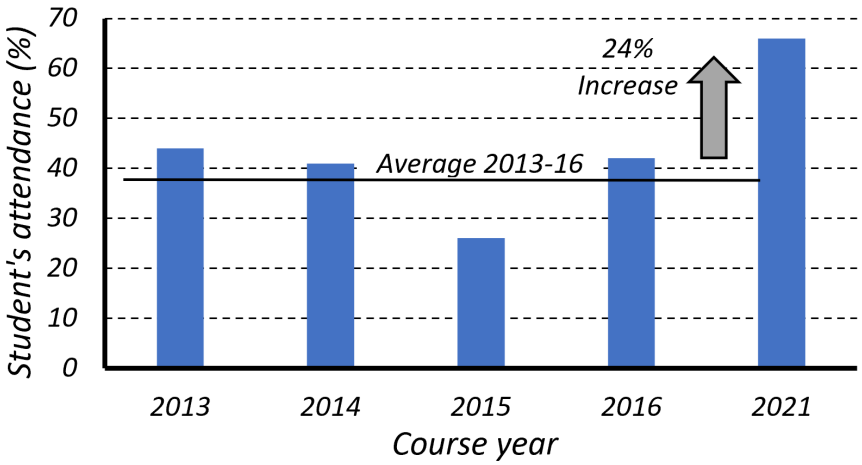

Figure 10. Student's attendance comparison.

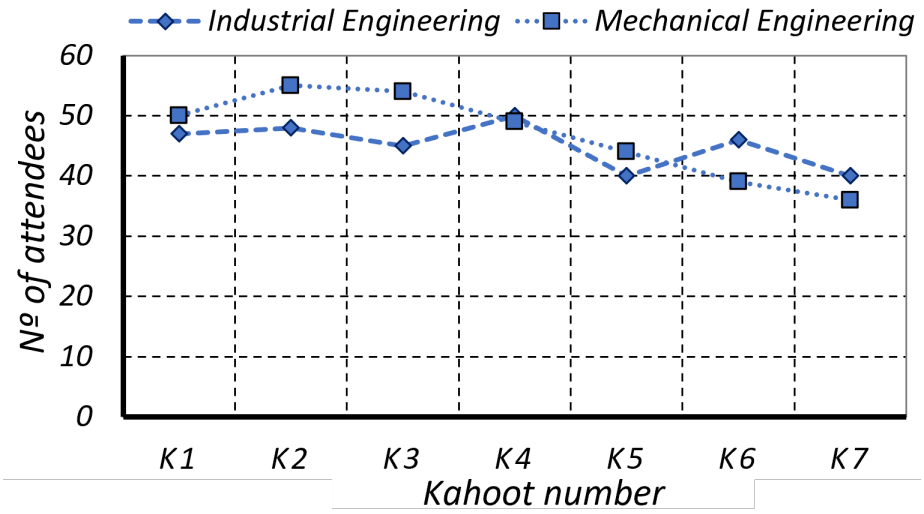

Figure 11. Attendance to the Kahoot tests throughout the course.

and therefore, the analysis of the number of visualizations is conducted comparing the courses 2018-2021. Figure 12 shows the total number of visualizations of the problem collections regarding metrology, bulk deformation processes and machining processes. In order to take into account the number of enrolled students per year, the indicator of

number of visualizations per enrolled student is shown in Figure 13.

As it can be seen, there is a clear increase on the number of views, specially in the total amount of views. It is worth noting that, due to the restrictions applied because of the COVID-19 pandemic, the order of the global units was rearranged this year, and machining problems were evaluated in one of the midterms instead of metrology. This would explain the higher amount of visualizations in machining during 2021, while the visualizations related to metrology is not as high as could be expected. Considering the total number of visualizations, it is clear that student engagement was achieved and an average increase of visualizations with respect to the average of previous courses was 44%.

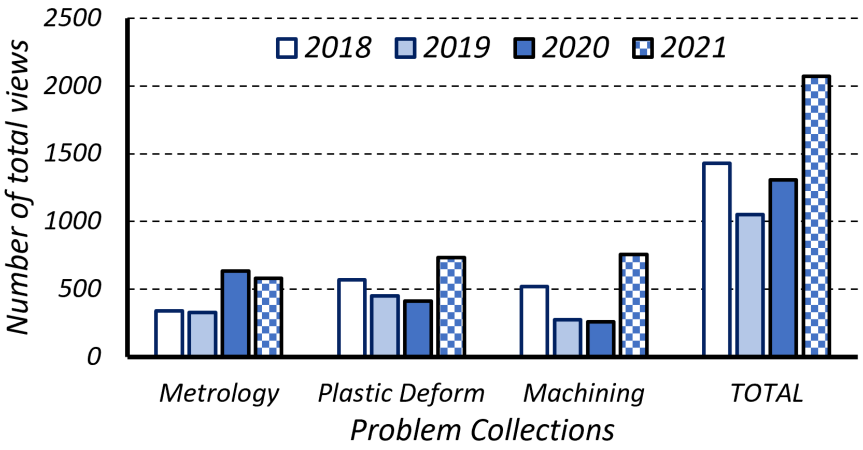

Figure 12. Number of views of the Problem Collections.

In relation to the student's performance, the KPIs about the number of students that have taken and passed the exam at the first and second call are shown in Tables 1 and 2. Two key conclusions can be drawn. First, the passing rate KPI considering the number of students that have taken the exam is not improved by the gamification experience, and the results at both first and second exam calls (49% and 62%, respectively), are within the common range of previous passing rates. Furthermore, the student's performance may be slightly improved in terms of higher grades, but there is not enough evidence for this claim. Please, note that these results consider the grades of the final exam without taking into account the extra points that the students may have gained during the gamificated continuous assessment.

The second conclusion is related to the number of students that have taken the exam. According to the results, the ratio of number of students that have taken the exam per number of students enrolled in the course is notably higher in 2021 than in

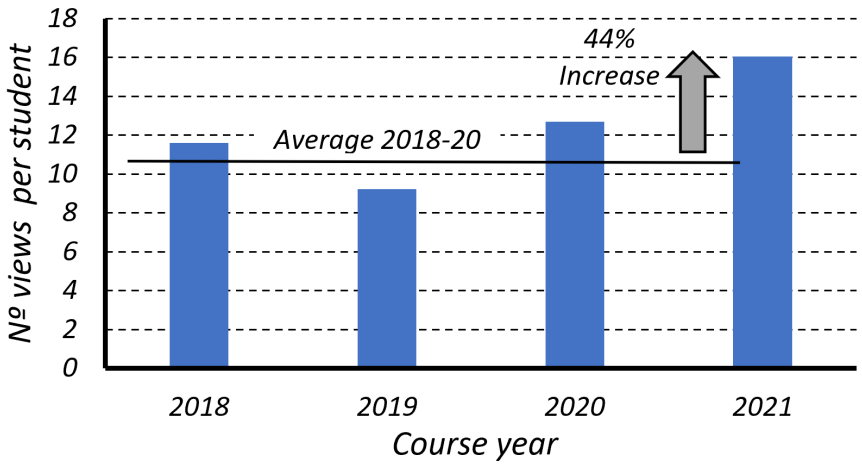

Figure 13. Number of views of the Problem Collections per student enrolled.

Table 1. Student's performance at first exam call

Year	Students enrolled	Passing Rate	Exams taken / enrolled
2013	68	30%	49%
2014	142	39%	51%
2015	144	45%	42%
2016	154	58%	49%
2021	135	49%	67%

previous courses. The average for the first call in previous years was a ratio of 48% whereas after the gamification experience the value increase to 67%. For the second call, the ratio refers to the number of students that have taken the exam per number of students that are enrolled and did not pass in the first call. The average of this ratio from previous years was 38% whereas the 2021 course was 55%. If one assumes that these ratios follow a normal distribution, the probabilities that the values given in 2021 were from the same normal distribution than previous years are 1.7% for the second call and less than 0.01% for the first call. Therefore, there is a clear positive effect on the number of the students that take the exam under this gamification experience. This can be explained by two reasons. Firstly, the student who have gotten an extra point do not want to lose it, so they prioritize this course over others. Secondly, even if they have not gotten an extra point, the fact of attending the classes and working weekly the contents may produce to the students a feeling of having more chances to pass the exam. It is important to remark that, although the passing rate per call seems not to increase, the fact that more students take the exam results in a final increase of the number of students that succeed, which actually leads to higher passing rates in global terms.

Table 2. Student's performance at second exam call

Year	Remaining students	Passing Rate	Exams taken / remaining
2013	58	71%	29%
2014	114	47%	45%
2015	117	60%	45%
2016	110	57%	34%
2021	91	62%	55%

Students' perception

The students' feedback about the proposed gamification approach is key to evaluate this educational experience. The answers gathered from the survey reveal several important results, and we highlight the answers of 4 questions in Figure 14. First of all, the student's feedback about the engagement and dedication has been highly positive. As shown in Figure 14-a), around 74% of the students indicates that the Kahoot activity has motivated them to stay in class and pay more attention to the instructors' explanations. Furthermore, 68% of the students ensure that the activity has enforced them to prepare and study the lessons weekly (Figure 14-b)) which is a very positive indicator to prepare the contents for the final exam. A numerical question from 1 (very low) to 5 (very high) was presented in order to quantify how useful the gamification experience was according to student's perception. As shown in Figure 14-c), most of the students answered 4 points and 3 points (51% and 26%, respectively), and only 12% of the students qualified the experience with less than 3 points which means a low or very low value for the experience.

Another key issue is the student's perception about the future use of the Kahoot activity and the Moodle exercises in this course. As it is shown in Figure 14-d), most of the students (86 %) deemed positive the application of this gamificated experience in the future because they considered that it helped them to study the course. As expected, no one answered that this activity is negative because reduces the time for lecturing, which confirms the low interests for lecturing sessions.

In general, the students confirmed that the proposed gamification experience is adequate. According to the survey, more than 80% of the students indicated that the extra point over the final grade is enough to motivate the students, and the time for answering the questions in the Kahoot was adequate. Some students propose to increase the scope of the students that can achieve an extra grade. Note that the current gamification experience gives extra points to about the 40% of the class, but it seems that some students feel discouraged when they realize that they cannot reach those positions at the end of the course, and tend to disengage from the gamification tasks. Although each global thematic unit lets the student to reach extra 0.25 points independent to the global score, it seems that for some students this was not enough.

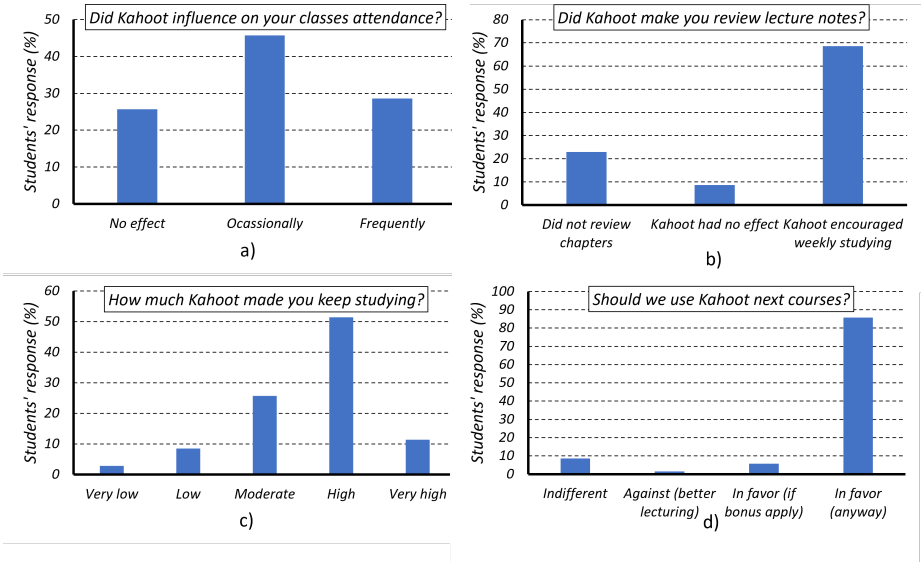

Figure 14. Results from the student's survey.

Instructor's perception

The instructors that implemented the gamificated continuous assessment offered several commentaries about this experience. They considered that preparing the multimedia material (Kahoot tests and Moodle-based exercises) implied an additional workload to their base duties. However, once the multimedia were programmed for the first time, modifying the statements and the problems was far quicker.

They also considered that the use of Kahoot during the theory sessions was useful for two reasons: the student's attendance was kept higher than other years, and the use of kahoots during the lectures serves them as a way to stop and reengage students when lessons are tough. However, they considered that during the Kahoot tests, the students did pay less attention to the explanations given by the teachers after answering each question, as they were more focused comparing their results with their peers. Trying to reengage them back prolonged the Kahoot tests over the expected time.

Some of the recommendations given by the instructors are:

- Change the test between degrees and even from year to year, since some students try to cheat knowing the questions in advance.
- Minimize the impact of time in the Kahoot points. The goal should be to answer correctly, not to answer faster. The time should be considered in order to reward the students, but with a less weight than the current one in the standard Kahoot.
- Emphasize the use of Kahoot for learning and not for just scoring. Under this gaming atmosphere, the students are more focused on comparing their results with their mates and making fun of the good and bad their performance was than

on learning why they were wrong. This is a key issue, since the goal of these tests should be to improve their knowledge not just to grade it.

Despite that, the instructors were quite satisfied with the performance results of this gamification experience. They also highlighted that the winners of each global unit leaderboard greatly valued the badges they earned.

Conclusions

This paper has shown a gamification experience on an large class in manufacturing engineering courses. The experience is based on Kahoot tests and Moodle exercises where the students compete among them to earn the maximum quantity of points in order to reach the best position in a leaderboard. These points are later converted into extra grades that are added into the final exam grade. The competitive nature of the activity encourages students to pay more attention in class, increase the time dedicated to study the contents, and read more often the collection of solved problems available at Google Sites. The results of this educational experience are highly positive. The student's attendance increased from 38% (average from 4 previous years) to 66%, the engagement in relation to the visualization of course contents (problem collections) increased by 44%, and the pass rate of the final exam in global terms increased from 22% to 34%. However, the improvement of student's performance in terms of higher grades is low or negligible. Furthermore, the student's perception about the gamification experience was very encouraging, since more than 70% indicated that the experience let them to prepare more properly the contents of the course, and around the 86% of the class indicated that the experience should be kept for the next years.

Acknowledgements

The authors would like to thank the Education Support Unit at the Universitat Jaume I and its financial support through the project for education innovation addressed to novice teachers.

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