Gamification as a Way to Reduce the Operating Method at Engineering Classes

Luis F Calvo Prieto, University of León, Spain
Raul Herrero Martínez, University of León, Spain
Ana I García Pérez, University of León, Spain
Sergio Paniagua Bermejo, University of León, Spain

The Asian Conference on Education 2018
Official Conference Proceedings

Abstract
As a result of the low grades found by the university students of engineering, the teaching staff of the second year of the Degree in Environmental Sciences, in the Faculty of Biological and Environmental Sciences of the University of León, proposes a plan of action on the students. The proposal goes in order to work on two aspects that are considered as vital when dealing with these type of engineering students. On the one hand it is proposed gamification as a way to reduce the stress with which students deal at university classes and ,on the other hand, it reduces the operative character with which the students try (in the wrong way in the judgment of the teaching staff) to solve the engineering problems raised in the cited subject. In this way, it was introduced a new concept for resolving the conventional engineering problems based in a game (for the incorporation of the gamification and produce a reduction of the stress). This game consists in to solve a problem without initial dates. The students have to obtain the dates choosing between several dates (some of them are no necessary for solving it) changing points for the dates. The objective is to know if this methodology improve the satisfaction of the students and their results in the subject. Then, with the present work, it has been shown statistically (t-Test of equality of means proceedings) that both actions improve both, satisfaction and results if we compare with a control statistically similar group.

Keywords: Academic stress, engineering problems, operativism, gamification
1. Introduction

University tutors usually consider that the stress of engineering students during learning period at University is not an important problem for them. However, current literature stated that university success could be improved if stress was considered during the learning period.

Previous experiences indicate that almost 75% of our engineering students suffer anxiety, fear and stress during the learning process at University and, in the same way, all the researches of our staff group consider that this situation is far away to be a good situation for the health of the students, and, therefore, for obtaining good academic results.

Therefore, the question that we have to consider is:
Is it possible to reduce the stress of ours students without the loss of academic rigour? Gamification is known as the process of game-thinking and game mechanics to engage users and solve problems (Zichermann & Cunningham, 2011). In this way, any game implicit in the concept of gamification must not only influence the psychological and social behaviour of the player. However, it must also serve to help the player to achieve some answers to certain problems, in such a way that the players, the more they play, the more time they want to dedicate to the game by increasing their comfort and the number of responses found (Kapp, 2012).

In addition, the second question to consider is if we introduce reducing stress factors in classrooms, can we improve our students capacities and labor skills?

In this sense, we are talking now about to improve the capacities and labor skills of our students reducing their operating method: we want thinking students and not mimic or simple operator students.

Johan Hizinga (1872-1945) was a Dutch philosopher and he was one of the first persons who worked in a pioneer project about the influence of the game in education process. In his book Homo Ludens (1938), he explained the influence of the game in the brain process of the players.

In this way, when we introduce gamification and learning based games we can improve the learning process of our students, reducing, at the same time, the common stress situations present in higher education.

It is important to know the difference between Game based Learning and Gamification videogames (Hamari & Koivisto, 2013).

Game based learning describes an approach to teaching where students explore relevant aspect of games in a learning context designed by teachers. Teachers and students collaborate in order to add depth and perspective to the experience of playing the game. Within an effective game-based learning environment, we work toward a goal, choosing actions and experiencing the consequences of those actions along the way. This keeps us to practice behaviors and thought processes that we can easily transfer from the simulated environment to real life.
Gamification is a different type of learning experience. Gamification takes game elements (such as points, badges, leaderboards, competition, achievements) and applies them to a non-game setting. It has the potential to turn routine, simple task into refreshing, motivating and mainly, reduce the stress situations in the engineering university class.

Although in our research group, we worked with both concepts, but in this paper, we are going to speak only about Gamification Learning, and we are going to introduce this concept in engineering classes by a free Application for Smartphones, this is to say, by the use of ICT.

Although there are many experiences of the use of ICT in the university classroom (Overland & Mindt, 2002), the use of the same by the student is conditioned to the educational approach given by the teacher, differentiating, according to (Galvis, Galvis, & Giraldo, 2015), between ICTs that support transmission, ICTs that support active learning and ICTs that facilitate interaction. However, the literature does not consider the existence of an ICT that involves a profound change in the way of solving problems by engineering students, reducing their operational procedure to make way for a much more rational model and close to their future work. (de Sandoval & de Cudmani, 1992).

2. Objectives

2.1. General objective
The main goal of this research is to destroy the pure operating method used for students to solve engineering problems. Our initial hypothesis is that we can obtain an improvement of engineering students academic results by reducing stress conditions using a gamification model based in PWD (Problems without Data). For that, we have to specific objectives.

2.2. Specific objectives
a) Design a gamification model based in PWD (problems without dates) that allows to our engineering students reduce learning stress conditions and mimic or operating conditions to resolve engineering problems, improving, in the same sense, the thinking conditions of learning.

b) Verify, in statistical terms, that gamification model based in PWD (problems without data) meet with the stated purposes

3. Methodology and methods

3.1. Statistic population
In this research, we worked with 67 students who studied the Environmental Science Degree at University of León (Spain). All of them were studying one subject called Principles of Environmental Engineering during the academic course 2016-17. They are scientific students, but this subject is an engineering subject, so the capacities that they have to acquire are different to the capacities of other subjects of the Degree.

Without considerer any variable (it is to say, randomly), the students were divided in two groups. In one side, students who followed Gamification Model based in PWD by the utilization of our original application for smartphones called BINQUI (acronym of
Principles of Chemical Engineering in Spanish); in the other hand, students who don’t followed that model and they utilized the classical way for teaching in engineering classes at University (with blackboard).

3.2. Methodology
Gamification model based in PWD (problems without data) was implement with a free App available for both, IOS and Android. I invite you to download it and, in this way, you can analyse how it runs. In essence, students create a profile in the app and, after that; they can observe that the app has set of problems placed in increasing order of difficulty.

These problems have no data inside the text of the problem, and, for that reason, students have to “buy” (not with money, obviously, they buy data through spending points).

There are two important things for a better understand of gamification process:
- Not all data are necessary to solve a problem
- A same problem can be solved in various ways, spending more or less points.

In this way, the student who resolve spending the fewest quantity of points will be the winner, and the App shows a ranking including time to solve it.

Students will be fully aware, from the first day of class, of their participation in the proposed dynamic as well as the objectives pursued. The breakdown of operating method followed by students when they solve certain questions will be encouraged.

In resume, the main idea that we have to learn is that one of the most important capacity for them is to know what dates they need for solving an engineering problem. In the first place, it could happen that the students react surprised to this proposal. Likewise, ambiguity must be avoided in order to students can focus on the correct resolution of the problem. Ambiguity, or, in other words, open situations, is an essential characteristic of genuinely problematic situations, being one of the fundamental tasks of scientific work to limit the open problems and impose simplifying conditions. In addition, it is the best way to simulate the labour conditions out of the university environment. Another setback that can be pointed to this type of dynamics refers to the possibility of eliminating the data and precisions of the usual problem definitions and constructing more open problems able to eliminate a resolution according to the characteristics of the scientific work. In this regard, the experience of the teachers involved in the activity has made possible to verify that the usual problem definitions are easily "translatable" to general problems statements without data.

3.3. Measuring instruments
In order to know if the targets have been achieved, it will be necessary to collect a series of data that allow the results evaluation of the proposed activity. In this way, to assess the degree of achievement, the use or non-use of the App will be evaluated as an independent variable (considering if it has been downloaded or not). A relation between this variable and the student academic result of the student will be sought (evaluating both the subject pass and the final grade).
3.4. Reliability and validity of the measuring instruments

This paragraph encompassed an explanation about how the different variables have been measured to guarantee their validity and reliability.

a) **BINQUI.** It means if the student used the App named as “BINQUI” for the exam preparation. The value of this variable is collected directly from the interface of the App Manager”, which guarantees the validity (measures what you want to measure) and reliability (accuracy of measurement). “Use of BINQUI” is called by letter B and “Do not use of BINQUI” is called by letters NB. This is our independent variable.

b) **Stress of our students after the research.** Quantitative variable (on a scale from zero to ten) of the final stress of the student (after the research). We have measured this value with the Hamilton Anxiety Scale (Hamilton; Xiao-Wei et al. 2018) and it was called as Y2. This variable is a dependent variable.

c) **Academic results of our engineering students.** It is categorical variable related to the mark obtained by the student in the subject. It is a quantitative variable (on a scale from zero to seven) of the result of the student (after the research). We have called it as Y3.

3.5. Analysis of critical points and risks in the achievement of the goals

The realisation of the project implies a risk in terms of acceptance by the students, since it represents a radical change in the way of approaching the study of their university classes. The critical points referred to the students are listed below:

- Lack of confidence in the teacher.
- Absence of participation.
- Lack of seriousness.
- Lack of maturity of certain students.
- Other aspect not considered

Therefore, the development of the proposed tasks is related to a series of risks. Once these risks have been identified, strategies that minimize their impact or even prevent their appearance can be defined. The management of the work carried out has been based on the PDCA continuous improvement cycle and the UNE 166002 R & D Management Standard.

For the critical points identification, periodic meetings were established between the teacher and a representation of the students in order to know both opinions about the development of the activities. Likewise, to resolve the identified critical points, actions are proposed to be carried out in order to solve any problems.

4. Results and discussion

A free and without advertising App has been created. It was called “BINQUI”. Each student, after download and log in, has 200 starting points. A series of PWD (Problems without Data inside the text) related to the subject linked to this project will be presented. They must decide, among all the data offered by the application, what are necessary to solve them. The acquisition will be related to a decreasing in the students points (the more data they request, the more points they will spend). Once the problem will be solved, a ranking of players for that exercise can be
accessed. The first position will be for the student who, having solved the exercise has spent less points. It should be noted that in equality of points, the winner will be the one that has taken less time. A series of the App screenshots are depicted in Figure 1.

![Figure 1. Screenshots of the original application that allows the use of Gamification model based in PWD](image)

It is necessary to clarify that App use has been voluntary. This fact allowed the authors to form two students groups according if the employed or not the App. The variables used in this work were the shown in Table 1.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Name of the variable</th>
<th>Escale</th>
<th>Measurement range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of BINQUI (independent variable)</td>
<td>BINQUI</td>
<td>Nominal</td>
<td>0: no 1: yes</td>
</tr>
<tr>
<td>Stress of the student after the research</td>
<td>Y2</td>
<td>Quantitative</td>
<td>0-10</td>
</tr>
<tr>
<td>Academic Results of our students</td>
<td>Y3</td>
<td>Quantitative</td>
<td>0-7</td>
</tr>
</tbody>
</table>
4.1. Statistic descriptive results

Table 2 shows the statistic descriptive results of the variable called Y2 obtained by SPSS statistic program for both: the group of the students that did not followed the proposal methodology (Y2NB) and the group of the students that followed de gamification model based in PWD with the use of BINQUI (Y2B).

Table 2. Statistic descriptive results of Y2 (Stress of the students after the research)

<table>
<thead>
<tr>
<th>Variable Y2 (Stress after research)</th>
<th>Statistic</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y2NB</td>
<td>Mean</td>
<td>5.9767</td>
</tr>
<tr>
<td></td>
<td>95% Confidence interval for mean</td>
<td>Lower bound</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>6.0000</td>
</tr>
<tr>
<td></td>
<td>Variance</td>
<td>3.8330</td>
</tr>
<tr>
<td></td>
<td>Std. Desviation</td>
<td>1.9578</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>9.0000</td>
</tr>
<tr>
<td></td>
<td>Kurtosis</td>
<td>0.5370</td>
</tr>
<tr>
<td>Y2B</td>
<td>Mean</td>
<td>3.4583</td>
</tr>
<tr>
<td></td>
<td>95% Confidence interval for mean</td>
<td>Lower bound</td>
</tr>
<tr>
<td></td>
<td>Median</td>
<td>4.0000</td>
</tr>
<tr>
<td></td>
<td>Variance</td>
<td>1.4760</td>
</tr>
<tr>
<td></td>
<td>Std. Desviation</td>
<td>1.2151</td>
</tr>
<tr>
<td></td>
<td>Range</td>
<td>1.0000</td>
</tr>
<tr>
<td></td>
<td>Kurtosis</td>
<td>-0.4350</td>
</tr>
</tbody>
</table>

We can observe that the stress of the students that did not followed the gamification model based in PWD was 5.98, but if BINQUI has been used this variable takes a value of 3.46, almost 1.5 points lower. In this sense, we can verify that the stress situation of our students has been reduces when they have been used BINQUI in their learning process. These results are agree with results showed in current literature about the use of gamification in learning process (Leah S., et al 2017; Joana D. 2017; Chris P., et al 2016).

Table 3 shows the statistic descriptive results of the variable called Y3 obtained by SPSS statistic program for both: the group of the students that did not followed the proposal methodology (Y3NB) and the group of the students that followed de gamification model based in PWD with the use of BINQUI (Y3B).

We can observe that the mean values if BINQUI was not used is 1.67 but if BINQUI has been used this value is 3.19. This is a very important difference and we can verify, with these dates, that academic results of the students have been improved.
Table 3. Statistic descriptive results of Y3 (Academic results of our students after the research)

<table>
<thead>
<tr>
<th>Variable Y3 (Academic results)</th>
<th>Statistic</th>
<th>Std. Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Y3NB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>1.6653</td>
<td>0.1687</td>
</tr>
<tr>
<td>95% Confidence interval for mean</td>
<td>Lower bound 1.3250</td>
<td>Upper bound 2.0057</td>
</tr>
<tr>
<td>Median</td>
<td>1.5300</td>
<td></td>
</tr>
<tr>
<td>Variance</td>
<td>1.2230</td>
<td></td>
</tr>
<tr>
<td>Std. Desviation</td>
<td>1.1059</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>4.1000</td>
<td></td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-0.6140</td>
<td>0.3358</td>
</tr>
<tr>
<td>Y3B</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>3.1896</td>
<td>0.3358</td>
</tr>
<tr>
<td>95% Confidence interval for mean</td>
<td>Lower bound 2.4949</td>
<td>Upper bound 3.8843</td>
</tr>
<tr>
<td>Median</td>
<td>3.2800</td>
<td></td>
</tr>
<tr>
<td>Variance</td>
<td>2.7070</td>
<td></td>
</tr>
<tr>
<td>Std. Desviation</td>
<td>1.6452</td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>6.5000</td>
<td></td>
</tr>
<tr>
<td>Kurtosis</td>
<td>-0.4520</td>
<td>0.9180</td>
</tr>
</tbody>
</table>

4.2. Test of equality of means for Y3

If we analyze the mean values between the use or not of BINQUI in the different variables, we had to verify the parametric conditions that t-Test considers:
- Sample size greater than 20
- Variables have to be quantitative variables
- We will have in consideration the equality of Variances
- The Normal distribution of the variables in verified using normality test Kolmogorov Smirnov way and Shapiro Wilk way, with Lilliefors Significance Correction.

For all t-Test we have the next conditions:
- Setting up the null (H0) and alternative (H1) hypotheses. Null hypothesis H0: the means of both considered group are similar in statistically terms; alternative hypothesis H1: the means of both considered group are not similar in statistically terms.

Justified choice of the statistical test. Considered variables are quantitative variables and they verify parametric conditions, so the most suitable statistical test to be considered is the t-Test. Moreover, SPSS provides the possibility of carrying out some symmetric and directional trials based on this parameter.

Significance level ($\alpha$). We have worked with an error rate of 0.05.

Definition of the sampling distribution. The sampling distribution is a probability distribution consisting of infinite values of a t-Test distribution, which is obtained from infinite random samples of the same population, all of them having the same sample size than the one of the research problem.
Rejection region or critical region. The rejection region of H0 is a part of the sampling distribution made up by the values whose probability is lower than or equal to 0.05 whenever the null hypothesis is true.

In this sense, table 4 shows the results of t Test of equality of means of Y3 (academic results of our students)

Table 4. t-Test equality of means for Y3

<table>
<thead>
<tr>
<th>Variances Assumed</th>
<th>F</th>
<th>Sig.</th>
<th>t</th>
<th>df</th>
<th>Sig. (2 tailed)</th>
<th>Mean Difference</th>
<th>Std. Error Difference</th>
<th>95 % Confidence Interval of the Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equal variances assumed</td>
<td>5.398</td>
<td>0.023</td>
<td>-4.525</td>
<td>65</td>
<td>0.00</td>
<td>-1.5242</td>
<td>0.3369</td>
<td>-2.1970 - 0.8515</td>
</tr>
<tr>
<td>Equal variances not assumed</td>
<td>-4.056</td>
<td>0.00</td>
<td>34.850</td>
<td>34</td>
<td>0.00</td>
<td>-1.5242</td>
<td>0.3758</td>
<td>-2.2872 - 0.7612</td>
</tr>
</tbody>
</table>

When we do the t-Test for equality of means with variable Y3 (academic results of our students), we cannot accept the Equality of Variances (signification >0.05) with a signification of 5 %. In that case, the mean of both groups, with 5 % of signification again, is different using statistical terms. That is to say that the use of BINQUI (gamification model based in PWD (problems without dates) improve the academic results of our environmental engineering students.

5. Conclusions

The main conclusion of this research is that the use of gamification model based in problems without dates (PWD) improve academic results of our engineering students reducing learning stress conditions. In this sense, we have obtained the answer for the two specific objectives considered.

On the one hand, we have designed an App for smartphones that introduce two concepts to our students: gamification (similar to no stress) and reduction to the operativistic wrong model for solving problems; on the other hand, we have verified, in statistical terms, the conclusions of this research.

7. Acknowledgements

We want to be pleasure with the programme PAGID from University of León that subsidized this research.
References


Contact email: Dr Calvo Prieto, professor at University of León (Spain)
lfcalp@unileon.es