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OPERATING METHOD AT ENGINEERING CLASSES: A TWIST IS NECESSARY

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Abstract

This work aims to transform the conventional class based on simple problem solving by active playful dynamics, in which each student participates actively as a role-play with his/her peers. It has been detected that the way that students have to face the resolution of an engineering problem goes a long way from how it would be solved in the world of work (students are accustomed to raise the resolution of an exercise according to the data that they have). However, the real experience is not so, but it is precisely the acquisition of data, and more specifically, the knowledge of what data to acquire, the real problem in solving this type of exercises. In this sense, a series of play activities were carried out (including the generation of an App) in order that students value the importance of the acquisition of data for the resolution of a problem. The conclusion obtained from this work indicates, on the one hand, the distance between the conventional teaching methodology used and the actual methodology to be applied and, on the other hand, this work presents the new dynamics proposed as a bridge to unify these differences.

Keywords

Engineering Classes, Operating Method, Problems Solving

1. Introduction

The role of adults as a model and a mirror, even at the university level, is one of the main keys in education. Teachers are models or referents, since, through their comments and reactions, they give students information about the image they have about them. Information that significantly affects their self-esteem (Schmetzer, 2005). Therein lies the need to take care, throughout the period that we are at university, about denoting to the students a permanent and coherent attitude in four lines of action:

1. - Positive models. Teachers must try to take a positive attitude and optimism in life and the daily circumstances that take place in the classroom. The calm, the joy and the valuation of the positive must be the thread of our teaching activity. This does not mean neglecting the negative; it must be taken into account but deal with it courageously.

2. - Positive expectations. It is about using the Pygmalion Effect, but in a positive sense. We must be aware of the strengths of our students and reinforce them in all their achievements.

3. - Positive language. Our communication with students must be impregnated with positive messages. This does not mean that we do not see the negative side of things, but we will try, in that case, that our language labels behaviors and not people.

4. - Model of strengths. Our model role will also be taken into account in the development of one of the 24 class strengths (established by Peterson and Seligman, and defined as "morally valuable styles of thinking, feeling, and acting that contribute to a full life"). Of course, teachers are not perfect with regard to human virtues, but we can aspire to them and our students perceive that we do. That is, it is of little use to pretend that our students enhance kindness if we do not do it with them.

These four lines of action will be enhanced by involving the students in them. It is demonstrated that as the involvement of students in their educational process increases, concentration, enjoyment and interest are greater, as stated by (Lucas & Schwartzstein, 2016). To do this, it is necessary to involve the students in the dynamics to be developed in university teaching. For this purpose, it must be taking into account that (1) the students perceive the activities as a challenge, and that they are meaningful for them, (2) that suitable contextual conditions are given, especially in the corporate work that is related to the activities to be proposed and (3) that there is an adequate relationship between cognitive and affective elements (not neglecting the role of positive emotions).

According to the above said, students should be fully aware, from the first day of school, of their participation in this type of dynamics, as well as the objectives that are intended to achieve (destruction of operating method in problem solving and reduction of stress level). In daily educational practice, it is frequent to observe a separation between the more academic aspects of the curriculum, linked to the domain of the content of the areas, in front to the aspects related to the personal development and the well-being of the student during his learning work (Park, 2004). Although it is true that in the Spanish university there is a so-called "tutorial action" (teaching to think, teaching to coexist, etc.), these are often relegated to the background, making it difficult to develop the content that entails. Content such as this proposal is centered

on demonstrating that happiness and playful learning within the university classroom is compatible with academic learning.

Regardless of the ego that certain teachers may have, as well as the lack of children's attention, the lack of evaluation teachers or de parents' attitude (Junpho, 2017) educators often make the mistake of thinking that the well-being and happiness of our students will occur in the future, conceiving the moment of their learning as an endowment of knowledge, skills and attitudes, without paying attention to the personal situation in which these are achieved (Psillos, 2003). Moreover, it could be said, and this is demonstrated by more than 75% of the students questioned, that academic teaching in the university environment, not only does not generate happiness, but causes anguish and successive moments of stress (Sánchez, Osorio & Molina, 2016). It may be wonder if, in addition to teaching skills, knowledge, etc., educators can teach students to enjoy their time in classrooms and university libraries. Even the management of social networks, as stated in (Smith, 2017), can imply a boost in the teacher - student relationship. All of these techniques and methodologies to help foster the pupil / teacher relationship are included under the so - called cooperative learning (CL). To achieve this learning, the findings (Almulla, 2016) suggest continuous personal development on both sides to help teachers to change their perceptions towards training as well as their views on classroom roles, responsibility and authority

In this way, and having as transversal competence the development of two key concepts in Positive Teaching Psychology (mindfulness and personal strengths), it is proposed the arduous task of transforming the classical dynamics based on problem solving using board and chalk in active dynamics in which the student participates as a role play with his/her classmates. Moreover, these dynamics try to correct a very important problem noticed in the university classrooms. This problem is related to the way that students have to face the resolution of an engineering problem in the classroom as well as in their learning procedure. This form is far from how the same problems would be solved in the world of work. In addition, it has been observed that when a problem is proposed to the students, they compile the data available in the statement and begin to investigate the formula in which they can enter that data to obtain a numerical result, which can be or not the answer to the question. However, in the industrial sector, when, as workers, students have to solve any situation, they will not have magic formulas or the exclusively necessary data (de Sandoval & de Cudmani, 1992). They will be the ones who have to consider the way forward to solve the situation, and, depending on this way, they must

decide which data they need among those available and if it is worthwhile or not to request analytics or data measurements that are unknown. In this way, it will be much more effective a person who spent the least amount of budget on measurements to solve the problem (Gabel, 1993).

Based on the above, it is intended to innovate in the way of solving engineering problems by university students. Conventionally, when solving a problem, the student is forced to look for those equations that relate the data and unknowns provided in the statement, thus falling into pure operating method. It is not enough, therefore, to denounce this method: its causes must be sought. The understanding that the presence of the data in the statement, as well as the indication of all existing conditions (all as a starting point) responds to inductivity conceptions and incorrectly guides the resolution (scientists have to search for the data they consider relevant , that is, they do not meet with them in an easy way).

The *main objective* of this work is the destruction of the cited operating method when solving engineering problems trying to open students mind when they resolve them. In order to achieve this goal, authors set themselves two specific objectives. The first one would be oriented to the generation of a series of activities in the classroom that serve as a preliminary stage prior to the use of a mobile application (App). The second objective would be the design of the app mentioned above. Application through which, in a playful way, students are made aware of the need to solve problems without using the classic and inefficient operating method.

2. Activities Performed

2.1 Activity one: “The engineer’s hardware store”

To reach the first objective, authors tried to transform the university classroom into a game board. First, the students presented a statement with a problem to be solved but lacking initial data. The question that can arise immediately should be ambiguous. It could be said that ambiguity and/or open circumstances are essential characteristics of problematic situations, being, in addition, one of the fundamental tasks of scientific work, for example, to limit open problems and impose conditions that simplify them. Ambiguity is also the best simulation of working conditions in the real life after finishing university studies. Another difficulty that can be pointed to this type of dynamics is the possibility of eliminating the data and precisions of the habitual statements and constructing more open statements, capable of generating a resolution according to the characteristics of the scientific work. In this respect, the experience of the

teachers involved in the activity has shown that the usual statements are easily "translatable" to general statements without data.

As already mentioned, the proposed activity is a business simulation in which, by groups of students, they have to solve a situation similar to reality (which is no more than a simple adaptation of a problem without data).

In order to arrive at a solution, students, starting from an initial budget, have to simulate the "purchase" of the instrumentation necessary to acquire the data they need (for example, if they need a temperature, they should understand that they need a thermocouple to get that temperature value). The dynamics is conceived as entertaining and playful, like if they were at a role-playing game with their friends. Students would perceive, in this way, that there may be several possible ways to reach a solution to a problem and can assimilate the practical implications that have, besides arriving at the correct solution, choose the most economical and fast way to do it. Despite having a winner (who first solves the problem by spending less from the initial budget), special emphasis was placed on not encouraging competition, but possible partnerships among the formed groups.

2.2 Activity two: "Design of a mobile App: Bases de la Ingeniería QUÍmica (BINQUI)"

Encouraging the playful character during the student's learning process, the previous activity was completed with the generation of an App to recreate the activity described above. Each student, upon registering in the application, has 200 starting points. Students have to solve different problems related to the subjects in which they are enrolled and that affect this project. These problems, as already mentioned, have not data to resolve them. The students must decide, among all data that offer the application, which are really necessary to solve the problem and can acquire that data using their points (the more data they request, the more points they will spend). Once the exercise is resolved, a ranking of players for that exercise can be accessed. The first position will be for the student who, having resolved the exercise, has spent fewer points; that is, the player with the most points wins. In case of equality, the one that has taken less time will win.

This App has been designed to count with several sequential exercises of increasing difficulty. The sequence is conceived as levels in computer games, so only after having solved the first exercise, is that the player can proceed to solve the second one (contrary to what happens in the usual methodology in which the student can move to the next problem without having solved the previous one). In any case, what is intended is to promote the character of play

through a closed system of problem progress, as is usually the case in online games of consoles and mobile devices. At any time, it will be possible to check the general ranking in which players' positions will be ranked according to the following criteria:

- (1) Number of exercises solved;
- (2) Points held;
- (3) Time spent.

In Figure 1 we can see a screenshot of the application showing an example problem and the possible data that can be acquired.

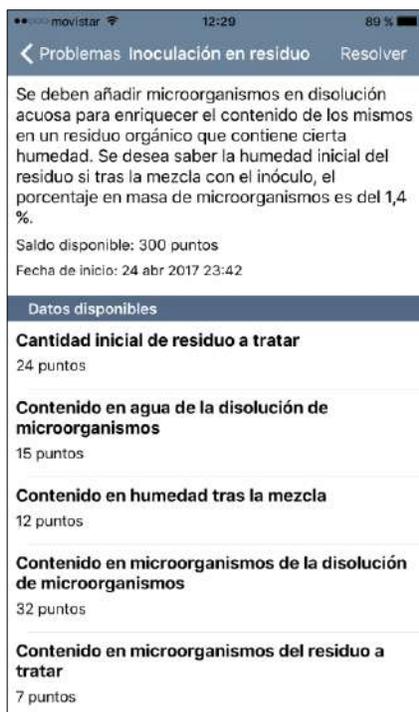


Figure 1: Screenshot of the application, example of a problem with data to be able to acquire. Note: The App Bases de la Ingeniería QUÍmica (BINQUI) is in Spanish

3. Activities Evaluation

In order to know the students degree of comfort about the activity one, satisfaction surveys were carried out. It was interesting to know both their opinion and their objective vision in achieving results as well as suggestions for improvement. In order to be able to know the actual teaching results of the activity, the academic qualification of the students participating in the activity was compared with the average of the three years prior to the application of the same.

4. Results and Discussion

With respect to the first line of work (realization of problems without data available in the classroom), it is necessary to indicate that it took a great effort (both teachers and students) to take on this type of dynamics. This was possibly due to the lack of habit to take part in this type of dynamics. Surveys carried out the first time that the activity was done, indicated that 53.7% of the participants were not comfortable during the course of this action. However, the same query was made the last time the activity was presented to the same participants, and this percentage significantly decreased to 7.8%. At the end of the experience, satisfaction surveys indicated that, for the subjects involved, students valued the dynamics very positively, especially noting the fact that attending classes became very enjoyable, even stimulating for the study and incorporation of new knowledge.

The statistical analysis of the results from the students' satisfaction surveys was carried out with the IBM SPSS Statistics v.23 software. From this analysis, a series of descriptive data were obtained, which are shown in Table 1. Descriptors from the statistical analysis clearly indicated the positive opinion of students about the activity (means of response above 8 points (on a scale 0-10) in virtually all cases). This implies that the students considered that, although the activity was raised and performed as a game, it served to reach the necessary knowledge to overcome the subject.

Table 1: *Descriptive for the Students' Answers to the Questions Asked*

Question related to*	Average		Variance		Confidence Interval			
					Inferior		Superior	
	M	F	M	F	M	F	M	F
1 Activity entertainment	9.16	9.20	2.091	1.265	8.37	9.63	8.6	9.57
2 Repeat the activity	9.44	9.30	1.656	1.664	8.7	9.82	8.57	9.48
3 Enjoy the activity without considering the qualification	8.57	9.72	8.542	0.328	6.95	9.4	9.48	9.9
4 Academic knowledge acquired	8.83	9.29	4.988	0.905	7.51	9.44	8.81	9.63
5 Think about the importance of social skills	8.39	8.78	3.312	2.874	7.52	9.09	7.92	9.39

* Students should answer a series of questions by evaluating the answers from 0 to 10, with 0 being the lowest score and 10 being the highest.

Regarding the distribution of the results, the sample size ($n < 50$) was performed by the Shapiro Wilk test to determine the normality of the results at a 95% confidence level. Analyzing this normality test, it can be affirmed that the data are not distributed normally, so the Kruskal Wallis test was carried out to evaluate the means of the answers according to the gender variable. The Kruskal Wallis test showed that there were no significant differences in responses to virtually all of the questions posed. Only for question 4 (“Have you enjoyed the activity regardless of the qualification obtained?”) significant differences between the responses of boys and girls were identified.

As for the academic results obtained, an increase occurred in the number of approved students for the three subjects considered, as shown in Table 2. Among the three degrees, the most noticeable increase of approvals was that of Biotechnology, followed by Agricultural Engineering and finally Environmental Sciences.

On the other hand, an increase in the final average grade of the students who participated in these dynamics was also observed. The increase of the final grade can be seen in Table 2 for the subjects and degrees considered. In this case, the most noticeable increase of the final grade was that obtained by the students of Agricultural Engineering, followed by Biotechnology and then Environmental Sciences students.

Table 2: *Comparison of the Academic Results after the Activity One*

Degree	Subject	Approvals without the experience *	Approvals with the experience *	Final grade increase*
Biotechnology	Bases of Engineering	74.5	95.2	23.8
Environmental Sciences	Bases of Environmental Engineering	33.2	47	17.3
Agricultural Engineering	Basic operations	79.7	94.3	37.6

* Results are expressed in percentage

After the evaluation of the activities, it can be said that the dynamics not only were perceived positively by students but also resulted in the improvement of their performance, so the objectives were fulfilled. Even so, improvements such as expanding student sample size as well as more complex evaluation techniques would be desirable. These aspects would be

reinforced in the near future, given that this work constitutes a good basis on which to develop more complex activities.

5. Conclusions

In view of the need to change the current operating method carried out by some students in the resolution of engineering problems, a series of activities were proposed (classroom role playing and an App generation) based on the resolution of engineering problems without initial data.

The experience indicated a significant increase both in the final grade obtained by the students participating in this activity and in the number of students who approved the subjects involved in the experience. In addition, although, initially, the proposed dynamic was not comfortable for 53.7% of the participants (teachers and students), this percentage decreased significantly (7.8%) once the advantages were verified.

The statistical descriptions also showed that it is necessary to do more work in future activities so that the students can recognize the benefits of the proposed activity while upgrading their acquisition of the social and job skills.

6. Scope for Future Research

Considering the tasks performed throughout this article, as well as the results and conclusions obtained, it can be affirmed that there would be an open line of research regarding the breakdown of the operational method in the engineering classes.

It would be advisable to implement a series of notions that would help keep the line and improve it. Some of the best that are proposed for future actions related to this article would be the following ones:

- Increase the population size of students to obtain more reliable and representative statistical data.
- Make it possible to use the app on certain platforms (ios, Android, Windows, Linux)

- Extend the use of the app not only to problems, but also to theoretical classes with summaries of classes
- Collaborate with degrees and similar subjects of other faculties (national or international)

7. Literature Review

In this section bibliographical references of related works are shown to be able to complete what is exposed in this article.

Milrad, M., Jackson, M. H., & Bergman, D. (2005, November). Exploring the potential of mobile services to support learning and communication in university classes. In *Wireless and Mobile Technologies in Education, 2005. WMTE 2005. IEEE International Workshop on* (pp. 107-112). IEEE.

With this article, authors tried to analyze the potential effect of using mobile phones at university classes. It would be advisable that readers consider our app results with the shown in this paper.

Krause, S., Decker, J. C., Niska, J., Alford, T., & Griffin, R. (2003). Identifying student misconceptions in introductory materials engineering classes. In *ASEE Annual Conf., Nashville TN*.

Here, authors made a list of the principal misconceptions that students have at engineering classes. This fact must be considered before start to work with university students.

Besterfield-Sacre, M., Atman, C. J., & Shuman, L. J. (1997). Characteristics of freshman engineering students: Models for determining student attrition in engineering. *Journal of Engineering Education*, 86(2), 139-149.

Although it is true that this reference is not so actual, it is considered as one of the pillars of every teacher to identify the problems of engineering students during their early years

Shukla, A. (2017). Constructivism and integration of ICT: Powerful blend of teaching – learning process. *PEOPLE: International Journal of Social Sciences*, 1(1), 82-90. doi:10.20319/pijss.2015.s21.8290

Though the pages of this paper, authors have worked with two investigation lines. While the first one encompassed the implementation of the ICT-enhanced constructivist learning today in classroom, the second one refers to the emerging need for the appropriate teacher education and professional development as a presupposition for the implementation of constructivist innovation in classrooms.

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<https://doi.org/10.20319/pijss.2015.11.3441>