Peer-reviewed version available at *Educ. Sci.* **2019**, *9*, 297; doi:10.3390/educsci9040297

Article

Non-Scientific University Students Training in General Science Using an Active-Learning Merged Pedagogy: Gamification in a Flipped Classroom

Francisco Zamora-Polo [1,2*], Mario Corrales-Serrano [3], Jesús Sánchez-Martín [4] and Luis Espejo-Antúnez [5]

[1] Departamento de Ingeniería del Diseño, Escuela Politécnica Superior, Universidad de Sevilla, Sevilla (España); fzpolo@us.es (F.Z.-P.).
[2] Departamento de Ingeniería Mecánica, Energética y de los Materiales, Universidad de Extremadura, Badajoz (España).
[3] Departamento de Didáctica de las Ciencias Sociales, Lengua y Literatura, Facultad de Educación, Universidad de Extremadura, 06006 Badajoz, España; mariocorralesserrano@gmail.com (M.C.-S.).
[4] Departamento de Didáctica de las Ciencias Experimentales y Matemáticas, Facultad de Educación, Universidad de Extremadura, 06006 Badajoz, España; jsanmar@unex.es (J.S.-M.)
[5] Departamento de Terapeútica Médico-Quirúrgica, Facultad de Medicina, Universidad de Extremadura, 06006 Badajoz, España; luisea@unex.es (L.E.-A.).
* Correspondence:fzpolo@us.es

Abstract: Innovative teaching strategies are designing a new and promising landscape in education. They fill up the lessons with creativity and imagination either for the students and teachers. This article addresses an attempt to make easier the approach to science in a non-scientific environment: primary education at university level. Gamification methodologies were combined with flipped classroom in order to free up in-class time and engage the students with the taught courses. A qualitative study was merged with quantitative measures of emotional and motivational parameters. These results were improved with four semi-structured interviews. The results clearly showed a raise in the students' motivational level, an acknowledgment of good teaching practice and an evident enhancement of felt positive emotions toward science teaching and scientific issues.

Keywords: Gamification; Science Education; Flipped classroom; Active Learning Methods; Higher Education.

1. Introduction

The need for an integral education in and outside the school is a clear claim nowadays. In this context, academic aspects and others such as civic education for a responsible citizenship should be considered [1–5]. Educators (at any level) should take education into account as a whole-comprehensive process, where the individual courses such as mathematics, literature or plastic arts should be no longer seen as unlinked containers, but pieces of a single puzzle. In this sense, there are many aspects that traditionally have played marginal roles from the structural point of view, but relevant ones if considered from an intrinsic point of view. This is the case of motivation, emotions, affective domain and so on [6].

Innovative methodologies are trending topic within the education spheres. Methodologies like flipped classroom, problem-based learning, design thinking or gamification are widely spread and many scholars are working on them, either at primary school level [7], high school [8] or higher education[5,9–14]. Despite the relative novelty of such initiatives, obviously all of them respond to a very old question that is already stated out from a long time: How to engage more and better the students in the education process, making it a real excellent event?

In this sense, we agree with Fried when he stated out that[15]:

> *"In too many classrooms we see the sound and smoke of note-taking, answer-giving, homework-checking, test-taking, and forgetting that so quickly follows. In the end, there is creativity and excitement for the few, compliance and endurance for the most, rebellion and failure for some; but not very much work of high quality is being produced, and not much intense engagement of the mind and spirit takes place."*[15] *(pp. 2-3)*

And some pages further: "The game of School is very pervasive, and its rituals are deeply entrenched in the actions and expectations of students and teachers. But it is not immutable. It can and must be changed" [15](p. 105) .

These and other reasons, most of them linked to the new socioeconomic paradigm, make the innovation within the educative general picture a real emergency, in order to obtain better results in terms of integral education. In this sense, it is not absurd to take some relevant precautions. We agree with Yowel in her statements about the adequacy of schools for experimenting[16]. Schools are not the place for testing new methodologies, she recently declared. Nevertheless, innovation must be implemented, and its results must be contrasted. This is the reason we think innovative strategies must be put into scene in higher education levels and dealing with those courses that, on one hand, usually have more difficulties to understand and pass some matters; on the other hand, they are those who will probably teach scientific concepts to children in the next years. For these reasons, our study is focused on prospective primary teachers in a general science course.

1.1. How to overcome the Doing-The-Same paradigm: some strategies and considerations

The basis of this work is we want (we need) to make science easier, closer to the students' interests and clearer. To this end, we began including gamification inside the standard lessons of General Science, with a relative success [17], but we wanted to go further and we discovered students liked playing. For this reason, in order to free up time from classes, we inverted the classroom by including flipping methodologies inside the gamification strategy.

1.1.1. Gamification

When talking about gamification, we assume this methodology as a modern technique for promoting the learning of almost every course. There are many approaches to a gamification definition; depending on the specific field it is applied. In a general way, we agree with De-Marcos et al. when they stated out that: "Gamification is the use of game elements and game-design techniques in non-game contexts, to engage people and solve problems" [18] (p. 82).

It is remarkable that gamification, according to this definition, is not constricted to educational areas. Moreover, gamification seems to be born for financial, marketing, economical areas. Some authors from these disciplines have attempted however very good approaches to educational gamification. This is the case of Zichermann and Cunningham when they stated the following:

> *"Games aligning entertainment and education like Civilization© and SimCity© have taught millions of people history lessons and the basics of urban planning. These are not pedagogical games. They weren't designed to be educational. But they use history and real city schema as a backdrop to explain ideas; thus, education becomes a byproduct of fun… So, can children learn from games? Absolutely. Research by Dr. Arne May at Germany's University of Regensburg clearly showed that learning a new task produces a demonstrable increase in the brain's gray matter in mere weeks. And brain scientists the world over agree that games' challenge-achievement-reward loop promotes the production of dopamine in the brain, reinforcing our desire to play."* [19] *(p. 4)*

Educational gamification can add an external motivation factor in the learning process [20], mainly due to the fact that an alternative framework for the educational challenge is built up on the basis of creativity behavior. Students should face the academic subject not only as a job to do, but as a game to play. And a game must be funny [21]. Gamification connects directly with the student's interest center and generates a positive attitude towards the study task. When asked about previous positive academic or instructional experiences, it is very common obtaining responses from students

Peer-reviewed version available at Educ. Sci. 2019, 9, 297; doi:10.3390/educsci9040297

like 'That teacher was great, (s)he taught us as it was a game', 'We learned as we were playing.' or 'His lessons were as he was telling us a tale'. The bases of the gamification were found long time ago, in a more or less explicit way, and in almost every subject. It is not a simple fortunate coincidence that a reference author as Robert Fried entitled a central chapter of his main work More ways to change the game of School [15]. One can find suggestive statements such as 'It means helping them (the students) begin each course, each unit, and each class as players, not as spectators' [15](p. 125).

1.1.2. Flipped classroom

Once educators realized that the engagement method for current students is no longer the traditional exposition (merely oral) or the common activities such as reading aloud, solving problems (by the teacher) on the blackboard or rapid question-answer dynamic where no debate or discussion is possible, others teaching strategies arouse in the recent years. One of them is called flipped classroom and it is defined by González-Gómez et al. as follows[22]:

> *"Flipped classroom teaching methodology is a type of blended learning in which the traditional class setting is inverted. Lecture is shifted outside of class, while the classroom time is employed to solve problems or doing practical works through the discussion/peer collaboration of students and instructors."*

It is remarkable that this mechanism allows the teacher to free up time inside the classroom (that is, the period while students are together with the instructor and amongst them) in order to invest the classroom for doing interesting things. Obviously, this methodology is much more than pushing the studying materials out from the physical classroom, it includes several elements that make teaching process more efficient. Some of them are the following ones:

1. When flipping a course, as a teacher you do not simply ask the students to read and study alone, at home, some materials. You select the most appropriate materials for understanding the contents; sometimes even you generate them (video tutorials, podcasts, documents, etc.). This requires you to choose attractive formats for the students. E.g., it has no sense asking them to watch a 45-minutes video when some studies have proposed that novelty disappear within 10 minutes [23,24].
2. If you achieve the students catch the dynamic of preparing the classes before the lesson, you can ask them to make their doubts and problems with the content prior the face to face session, so it allows you to make a just-in-time teaching [25]. This means adapting the exact teaching process and strategy to the current needs of the students.
3. One of the most struggling aspects of the flipped classroom is the fact that it implies a non-circular method for developing the content, so teachers are initially unable to check the knowledge acquisition. Despite this drawback, it can be overcome by implementing gamification measures (such giving rewards) or forcing the students to participate in the just-in-time teaching by asking questions or exposing what was not clear enough.
4. Once students are involved with this process, their participation with the course development increases highly, so usually the global academic marks are increased as well.

In a graphical way, Figure 1 presents the main differences between the classical oral-based lessons and the flipped methodology. As can be appreciated, this strategy demands higher level of students' implication, but allows to generate a more creative and exciting learning environment at school.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 31 October 2019 doi:10.20944/preprints201910.0363.v1

Peer-reviewed version available at *Educ. Sci.* **2019**, *9*, 297; doi:10.3390/educsci9040297

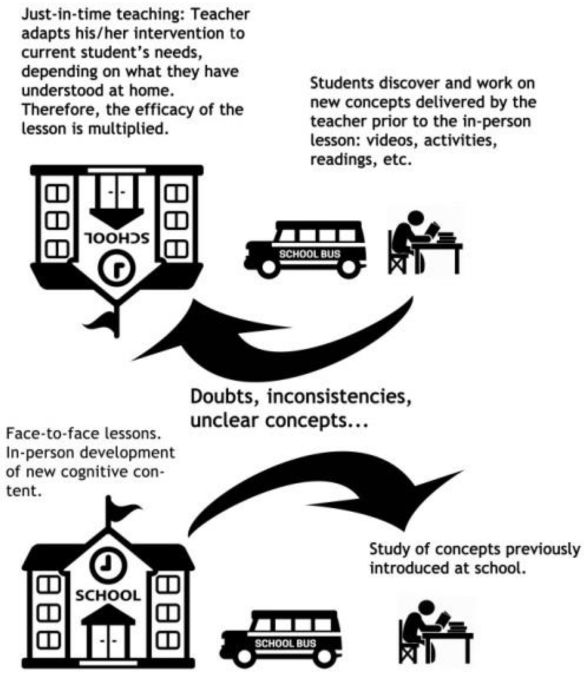

Figure 1. Flipped classroom model vs. traditional oral-based teaching model. Source: own elaboration from González-Gómez[22]. Icon credits: Emoji One, CC BY-SA 4.0 and www.onlinewebfonts/icon CC BY 3.0.

1.5. Teaching and learning science for non-scientific audience: a current challenge

If teaching in a more efficient way is, in general, a challenge for educators, making it when dealing with some specific issues can be even harder. This is the case of science, technology, engineering and mathematics subjects, namely STEM issues. It is commonly accepted that STEM subjects usually make negative or disgusting emotions to arise in those individuals that have experienced difficult in their learning [26] and this is worrying because that evidences that a bad emotional experience, in a high percentage, connects with a general rejection of science issues . The case of primary teachers is even more relevant because their negative experiences can be shifted to their students, children that probably will receive the same negative messages about science and science education [27]. This creates a vicious circle (Figure 2). The student had a bad experience with the subjects STEM in primary or secondary school, (s)he faced negatively at the University. Finally, (s)he transmits this experience to his students. Therefore, the circle is closed.

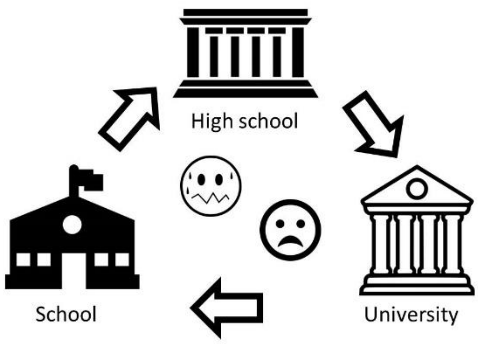

Figure 2. Vicious circle. Source: own elaboration. Icon credits: www.onlinewebfonts/icon CC BY 3.0

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 31 October 2019 doi:10.20944/preprints201910.0363.v1

Peer-reviewed version available at *Educ. Sci.* **2019**, *9*, 297; doi:10.3390/educsci9040297

The current trends in science education are aware of such importance of emotions, because there is no way of engaging students without taking their emotional performance into account, understood as the emotional response, positive or negative, experienced by a student when facing a particular course [28,29]. If this is relevant for teaching and learning whatever subject, it can be considered as a crucial aspect when teaching science, because usually science teachers begin from students' more difficult emotional position [30].

There is, consequently, a search for good emotions in science teaching. It is also known that the loss of these good feelings toward science takes place during the instruction process: children usually feel good when dealing with initial science issues (one just have to remember how (s)he felt when the teacher brought a plastic yoghurt glass filled up with cotton and a bean seed), but this feeling rapidly disappear once the years go ahead [31]. Gamification and flipped classroom are teaching methodologies that look for recovering this initial surprise and good feeling amongst university non-scientific students.

In the last few years, the use of gamification and flipped classroom is increasing substantially at different stages of education, however, the combination of the two has been least explored to date. The main objective of this research is to analyse the combined use of gamma and inverted class in science education in order to determine whether their combined use can have a positive effect on the development of teaching-learning process.

2. Methodology

This research has been carried out by merging several methodologies. Some of them are quantitative, measuring through surveys the students' motivation level. In order to obtain more information, a qualitative study based on the interview of selected students has been developed. Regarding ethical procedures, the participants who were interviewed gave us consent to be recorded, and to use their answers for our research with academic purposes. In order to maintain anonymity, all names used in the article purely fictitious.

2.1. Sample qualitative description

The study sample consists of 18 students, 10 females and 8 males, aged between 19 and 25. Most of them are 19-20 years old, the corresponding age for studying this 2nd year of pre-service primary teachers. They study in an Education faculty (not Science one or similar) makes this sample relatively different from others. The students are part of group number 4 (afternoon time). Usually, the size of this group is smaller than the groups taught in the morning. The low number of students (18) allows to introduce innovative actions. These actions, properly analyzed, can be replicated, with their corresponding adaptations, to larger groups.

The general profile of the standard student of this course deserves a specific description, based not only on quantitative data, but also and above all on personal and direct observation:

1. As Jeong et al. recently pointed out [32], the academic background of the students in this grade is mainly linked to social science or arts studies. Additionally, they do not identify the studies for becoming a Primary teacher as science discipline and obviously not many scientific contents are known for being a good primary teacher.
2. As a result of the previous item; traditionally linked to the scientific education values, for example: curiosity, observation, surprise, and so forth, are not present by default in the sample students. Even more, the initial emotions toward science issues in this kind of students are nearer to rejection rather than the personal interest [33].
3. The academic structure of the syllabus for Primary Teacher Grade includes a huge number of different subjects, belonging to a large variety of academic fields (arts, literature, physical education, music, history, geography, science, and so on) This has a direct influence in the importance and relevance students give to each matter. We observe that science education, since it is not an interesting subject for the students in this Grade, is put in the last place in importance order.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 31 October 2019 doi:10.20944/preprints201910.0363.v1

Peer-reviewed version available at Educ. Sci. 2019, 9, 297; doi:10.3390/educsci9040297

4. As a result of these circumstances, science education subjects are passed by the students with a relatively low academic marks [22].

2.2. Gamifying and flipped classroom activities

The general vision of the course included gamification activities. This was reported during the first days of the course. The general gamification proposal is fully described elsewhere [17], with a narrative linked to Star Wars™. The course included 30 sessions (90 minutes) that were systematically organized in the following way:

- The first 20 minutes were focused on discussing and clarifying doubts that could arise during the flipped period (before the face to face lesson). This corresponds to just-in-time teaching.
- Then, the teacher developed new content in an oral-based methodology for no longer than 20 minutes.
- The flipped and the classroom content were applied by doing some cooperative activity (problems, little research, etc.)
- Finally, a game-based activity was implemented for generating good feelings.

As can be appreciated, the students get into the lessons with a high level of participation. The oral exposition was constricted to a minimum time within the 90 minutes the classes took. This was made in order to engage the students to attend the classes, as the attendance is not mandatory at university.

Some game-based activities for playing inside the classroom were the following ones:

1. Classical board games such as Taboo™ or Time's up! ™ where the themes have been changed into those linked to the course's contents. For example, with Time's up! TM the definitions must deal with the universe and students must play describing concepts such as Terminal Shock, Heliosphere, Comet or Big Crunch.
2. Other proposals included little tricks for forcing the students to read, understand and study some concepts. This is the case of Match and Find, where the Presentation Slides and the corresponding explanation in comments were split off and students must put them together again.
3. An educative Escape Room experience, where students were confined in a classroom and several scientific and non-scientific challenges should be faced and solved for get it out.
4. Competitive questionnaires on and off-line: Kahoot™, Socrative™, Quizziz™ and other proposals were performed sequentially for checking out the knowledge acquisition.
5. Scientific coffee: Students were received at classroom with a free coffee and a paper napkin in their sites. Then, a very difficult problem with its corresponding solution was given, one different to each student. The purpose of this scientific coffee is to provoke a scientific talk (each student must explain his or her problem to the classmate sitting next) inside a relatively non-formal situation. The explanation, therefore, must be written down on the napkin.
6. Collaborative problems Jig-Saw: Several proposals of puzzles were given during the course. The entire problem was segmented into four or five parts that must be put together for facing the problem. Each part was given to a different student's team, so their collaboration was absolutely needed for the success of the whole group. An example of such activity is given in Figure 3.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 31 October 2019 doi:10.20944/preprints201910.0363.v1

Peer-reviewed version available at *Educ. Sci.* **2019**, *9*, 297; doi:10.3390/educsci9040297

Figure 3. Jig Saw activity scheme. Each team has only its corresponding piece of problem. Han Solo and other characters belong to Disney™ and Lego™.

A resources-based game structured the whole course, so students were able to obtain points that could be changed by benefits and advantages at the final exam. To this end, although those points could be gained during the in-person lessons, a parallel game based on working in teams outside the class was proposed. In this methodology, difficult problems involving the scientific concepts taught at class were proposed to be solved (out of class). An example of such proposals is given in Figure 4.

Figure 4. Presentation of a game-based problem for teaching Archimede's principle in gas fluids. The picture copyright belongs to Lucas™ and Disney™.

The flipped classroom materials consisted on a series of video-tutorials (made ad hoc) focusing on the most relevant points of each chapter: Archimedes' Principle, solutions and concentrations, moles and Avogadro's number and so on. Additionally, some aspects were developed by using written documents (no more than two pages each one) or other external links. The main goal of flipped classroom is to release part of the classroom time in order to use it to develop the most complex concepts (just in time teaching). Hence, time with professor can be leveraged and better academic results can be obtained. This methodology helps students to focus their attention in those relevant aspects that should be clearly understood. For guaranteeing the pre-work at home, students were rewarded with game points or other advantages if the post-survey (one for each flipped session) was filled out. Most students gave satisfactory feedback in these surveys and this participation rate reported the level of students' implication.

2.3. *Quantitative data collection: the surveys*

With the aim of collecting quantitative data, the whole experience involved the use of several surveys. Some of them were made in the classroom (written down) and some others were web supported (by using Google Forms™).

These surveys can be summarized into the following categories:

1. General surveys on participation level, regarding the flipped classroom activities. These were simply questionnaires that must be filled out prior to the face to face lesson. In them, teacher asked the students about doubts and feelings on the course they were working on then. An example of this kind of survey is given in Table 1.
2. Motivational surveys made before and after of the educational Escape Room). This has the purpose of checking a motivational raise in the general studies for pre-service teacher and for the current course (Didactics of Matter and Energy). In these surveys, students were asked to express their own level of motivation (1-10 scale) towards a) any class from the Degree, b) This specific class of Didactics of Matter and Energy and c) The next class of this course.
3. Emotional performance and science vision survey. A final evaluation of the subject, considering the active methodology. This included some quantitative items about the perceived difficulty in the subject itself and an evaluation about the active methodology. In addition, some questions were proposed for inquiring about the best and worst aspect in the subject development and about the way the student will remember the subject, both items as open-response questions. These last ones were considered as qualitative aspects (section 3.2).

Table 1. Pre-class questionnaire (example).

Pre-class questionnaire on pure and compound substances
Name

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 31 October 2019 doi:10.20944/preprints201910.0363.v1

Peer-reviewed version available at Educ. Sci. 2019, 9, 297; doi:10.3390/educsci9040297

Please give the name of three pure substances and explain the reason of such classification
Which aspect of the video-tutorial was most clear for you?
Which concept or idea was not clear enough with the explanation?
Please evaluate the video-tutorial with a mark (0-10)
Finally, send me an urgent doubt (something you do not understand well

2.4. *Semi-structured interviews*

In order to improve the study, quantitative research was complemented with qualitative one. This consisted on semi-structured interviews to four selected students. The selection was made considering the combination of two variables: initial motivation toward science subjects and initial basic scientific knowledge, so the four students presented the total feasible combinations as Table 2 presents.

Table 2. Selected students for qualitative interviews.

Student's fictitious name	Initial motivation	Initial science knowledge
Ana	High	Low
Roberto	Low	High
Marta	Low	Low
Blanca	High	High

The interviews were conducted through five main open questions (many others arose during the interview) that brought the opportunity for talking about the subject itself, about the science teaching and about the method the teacher carried out during the semester. These initial questions were the following:

- How did you feel when the subject was just started, at the beginning of the semester?
- Did you like science prior to studying them at university?
- What do you think about the method the teacher has followed with this subject? Do you think it is different from the rest of the subjects?
- Do you think this method motivates the student to study better? Why?
- Does the teaching method influence in the way the content is received by the student? In which way?

As this qualitative researching method recommends Patton [34], the interviews lasted for 30 minutes and then they were transcribed. The analyzed data were carried out on these transcriptions.

3. Results and Discussion

Data were processed by using statistical software package SPSS v.14 for Windows [35]. Due to the number of involved individuals (18 students attending), the results are a descriptive data landscape. In addition, their study together with qualitative interviews gave a consistent response to the working hypothesis.

3.1. *Quantitative results*

3.1.1. A difficult science vision

Students were asked about the perceived difficult of the course itself and the difficult of the exam. A quantitative 0-10 scale was given for choosing. The course was considered difficult (an average consigned value of 7.61) as well as the exam (with an average value of 7.65). In addition, the responses were correlated and a very high correlation factor (r^2 of 0.86). This means the whole consideration of the course, including the evaluation final test, was in agreement with those preconceptions about science and science teaching that other authors already reported [26,27]. Graphically, these results can be appreciated in Figure 5.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 31 October 2019 doi:10.20944/preprints201910.0363.v1

Peer-reviewed version available at Educ. Sci. 2019, 9, 297; doi:10.3390/educsci9040297

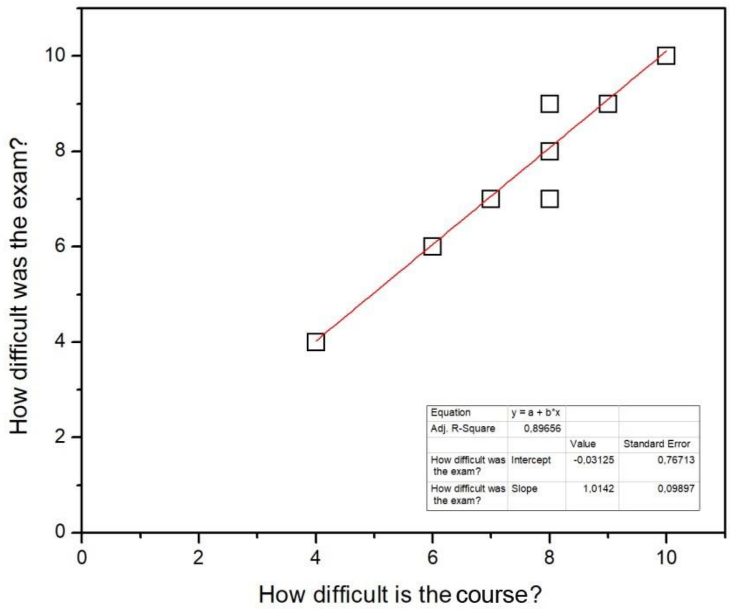

Figure 5. Correlation graphic between the perceived difficulty in the course itself (Didactics of Matter and Energy) and in the final exam. Right lower case: statistics of the fitting correlation.

3.1.2. The relevance of the teaching method

Although students did not experience the subject or the exam as easy, they were asked about the teaching method afterwards (that is, once the subject and the exam is over). The responses were again high enough for considering them as positive (average of 7.3). In order to compare the two assessments (teaching method and course difficulty) Figure 6 was built up. In it, the response frequency to both questions is showed, although the axes are inverted to make the comparison easier. As it clearly depicts, students responded with a high similarity to both questions and high rates are reached in them. There are only a couple of responses out of the 7-10 range. This means the students considered the teaching method as a good choice for science education, although we cannot distinguish whether they also consider these strategies advisable for prospective teachers.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 31 October 2019 doi:10.20944/preprints201910.0363.v1

Peer-reviewed version available at Educ. Sci. 2019, 9, 297; doi:10.3390/educsci9040297

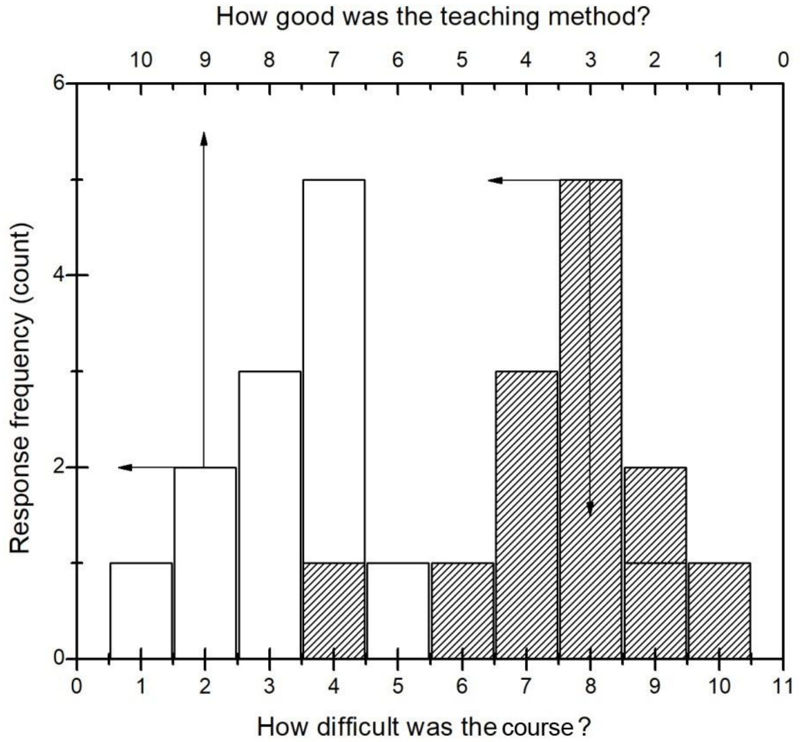

Figure 6. Responses frequency to the questions about the course difficulty and the teaching method.

3.1.3. Motivational raise due to innovative teaching methods

Figure 7 presents the motivational raise expressed by the implementation of the educative escape room, as part of a general innovation program in the course. The results confirm that students are more motivated towards the science classes after a gamified activity with a high level of participation, hands-on and funny aspects. As can be clearly seen, the motivation level raises for the three categories, but especially for the next class of Didactics of Matter and Energy. This confirms that, for this group of students, these kinds of activities enhance the motivation for the general studies (the whole degree) and above all for the science involved subject. These results are consistent with other experiences analyzing escape rooms [36–38].

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 31 October 2019 doi:10.20944/preprints201910.0363.v1

Peer-reviewed version available at Educ. Sci. 2019, 9, 297; doi:10.3390/educsci9040297

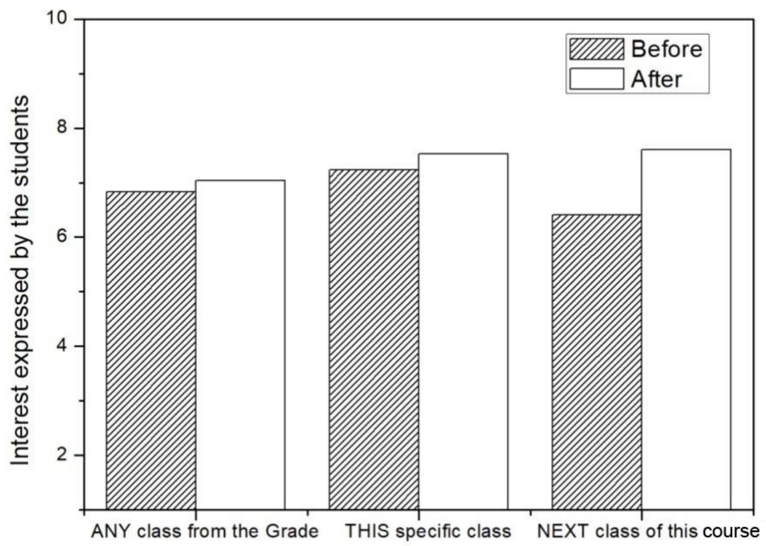

Figure 7. Motivational raise towards general classes in the degree and especially towards the subject classes before and after the Educational Escape Room activity.

3.2. *Qualitative results*

3.2.1. Open-ended answers

As section 2.3 presented, the last survey included two questions that should be answered with an open paragraph by each student. For this, they were asked to fill in the best and the worst aspect about the subject classes. Almost everyone agreed in pointing out the methodology (gamification, applied science, innovative teaching method) as the best practice, whereas the worst aspect was the perceived difficult of the subject and the problem solving.

Regarding the second question (How will you remember these classes?), the positive aspects of the teaching method were pointed out in a general way. Textually, students responded like the following:

> *`I will remember these classes as the best in the degree because of the methodology, but also as some of the most difficult ones.'*
>
> *`Intense'*
>
> *`A coffee with science'*

In general, the way the students expressed their ideas about the perception of the subject shows that innovative methodologies improve the emotional performance in the students, since it does not remove the difficulty, they detect in the science issues, but makes it more acceptable.

3.2.2. The interviews

The interviews were a great source of qualitative data. The first analysis of this material was made through data categorization. The transcriptions were coded for identifying four data categories: student, emotional expression, kind of emotion (positive or negative) and reason for such feeling. The descriptive results of the four interviews are presented in the following section.

a) Descriptive data

At a first glance, one must identify the frequency the students talked about their emotional experiences during the classes. Expressions like “I feel confused when facing the problem solving” or “From the first moment I felt curiosity. What was that called 'gamification'?” were coded as

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 31 October 2019 doi:10.20944/preprints201910.0363.v1

Peer-reviewed version available at Educ. Sci. 2019, 9, 297; doi:10.3390/educsci9040297

emotional references. The first one could be coded as negative feeling, whereas the second one was considered a positive emotion.

The total count on emotional references according to the different interviews is presented in Figure 8. Clearly, positive emotions are more frequent than negative ones (Figure 9). This is consistent with previously published work in the literature, for example Bujacz et al.[39] obtained a correlation of positive emotions with creative activities, Suwal and Singh [40] found mainly positive emotions in the use of the Building Information Modelling (BIM) methodology using an online platform, Jeong et al. proposed that active learning methodologies [12] and flipped classroom [13,32] cause positive emotions in students. On the contrary, Zamora et al. found a plane emotional performance in a project-based learning activity developed using BIM in the university context [11].

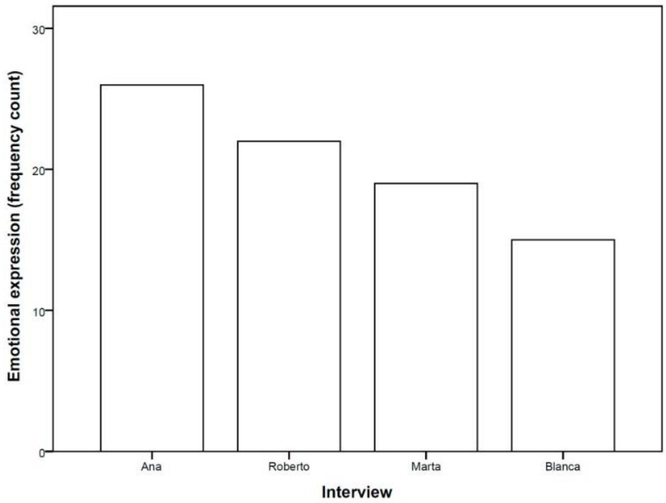

Figure 5. Responses frequency related to emotional references during the interviews.

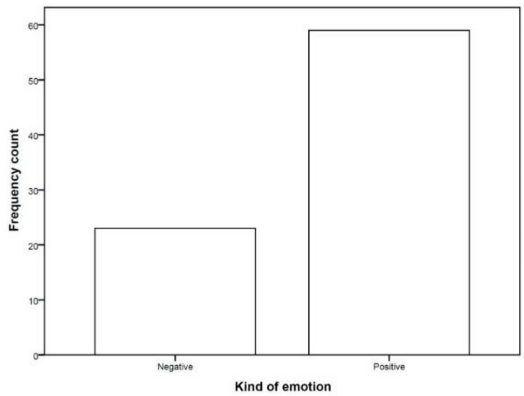

Figure 9. Kind of emotions (positive/negative) expressed by the students during the interviews.

In Figure 8 is shown categorized by students. A clear trend in the data cannot be observed. The student who used more emotional expressions correspond with a student with a high initial motivation and a low initial science knowledge (Ana); in the second place, a student with low initial motivation and a high initial science knowledge (Roberto). On the other hand, the student who used less emotional expressions is Blanca, a student who had initially a high motivation and science knowledge. These results seem to indicate that emotional outcomes depend more on the teaching-learning process than on the preconditions of the students.

Figure 10 shows the frequency account of different emotions. As can be seen from the graph, the three more positive emotions cited by students are motivation (22 times, 28%), pleasure (12 times, 14.6%) and excitement (6 times, 7.3%); on the other hand the three more negative emotions cited by

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 31 October 2019 doi:10.20944/preprints201910.0363.v1

Peer-reviewed version available at Educ. Sci. 2019, 9, 297; doi:10.3390/educsci9040297

students are fear (4 times, 5%), confusion (4 times, 5%) and anxiety (3 times, 3.7%). As can be seen, the generated emotions are clearly positive; the number of times that motivation appears is more than 5 times greater than fear or confusion. This fact clearly confirms the hypothesis 1, the methodology used enhance the students' emotional performance. These results are consistent with other studies than relate innovative methods with an increase in students' motivation [22,41].

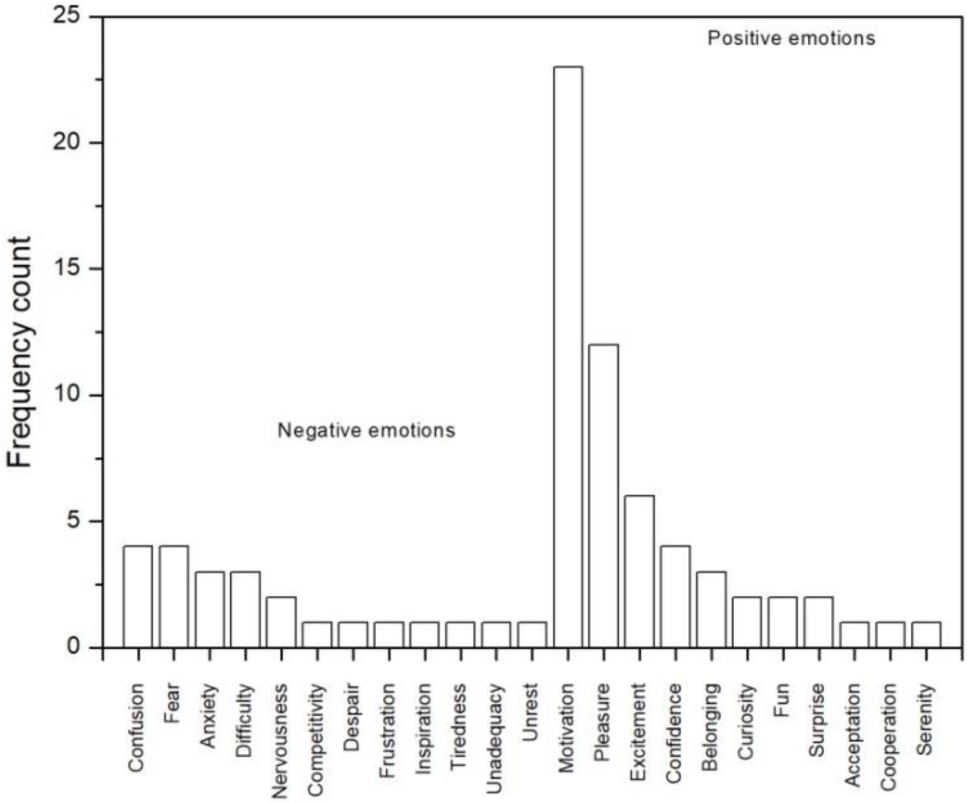

Figure 6. Emotions expressed by the students during the interviews.

Regarding the second hypothesis, two specific questions were asked in the interviews with the students: Do you think that what you have learned in class can help you in your professional future? Could you apply it to your classes?

Student number 1 (Ana) answered: "Yes, I think so, I would certainly like that. These methodologies are interesting and motivating. They make the classes easier, they are a good option"

Student number 2 (Roberto): "It depends on the students, for elementary school students I think it is a good option, the proposal should be designed and adapted for them; however, I would not apply these methodologies for adults."

Student number 3 (Marta): "Yes, I think so, yes. I really liked the games; cooperative learning is very interesting too. I think you can learn more from others than working alone."

Student number 4 (Blanca): "Of course! We have learned many methodologies. It is better to teach using an active methodology than using only theoretical classes. These contents should be introduced as soon as possible. Obviously, they should be tailored to students' age."

These answers show that students have acquired psycho-pedagogical skills alongside purely scientific skills. They have learned new methodologies and they are willing to apply them in the future with their students. These results confirm hypothesis number 2; students develop new skills that will allow them to become better teachers in the future.

These results are very important, they show how the vicious circle shown in section 1.3 is broken, creating a virtuous circle (Figure 11). Students faced STEM subjects with positive emotions.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 31 October 2019 doi:10.20944/preprints201910.0363.v1

Peer-reviewed version available at *Educ. Sci.* **2019**, *9*, 297; doi:10.3390/educsci9040297

They have a better predisposition to teach STEM subjects and are trained to introduce methodological improvements in the classroom in their work as future primary teachers.

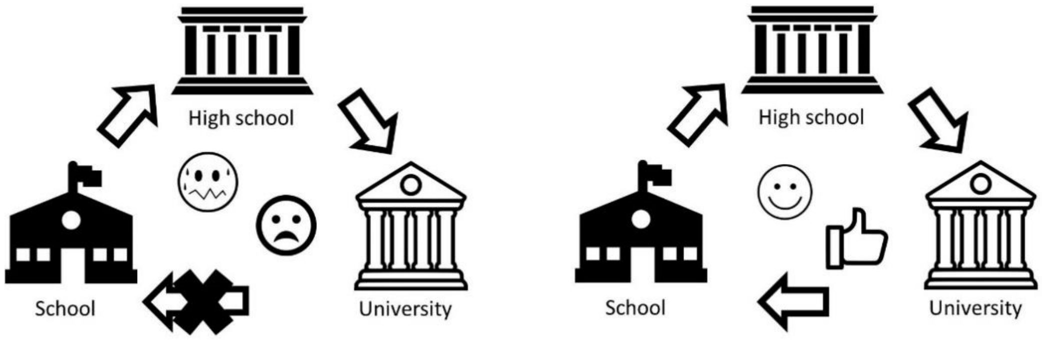

Figure 11. From vicious circle to virtuous circle. Source: own elaboration. Icon credits: www.onlinewebfonts/icon CC BY 3.0.

Finally, Figure 12 shows student's reasons related to their feelings, the more frequent are methodology (49 times, 59.8%) and current knowledge content (16 times, 19.5%).

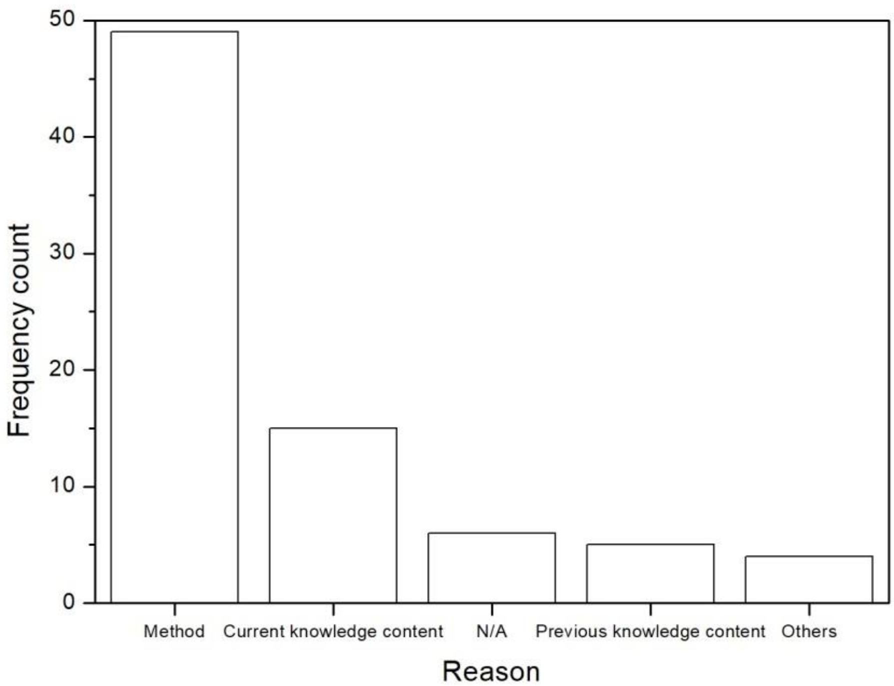

Figure 7. Reasons attributed by the students to their own feelings.

b) Inferential analysis

In order to get deeper in the analysis of the reasons for feeling one kind of emotion or another one, that is, to clarify whether the negative emotions are linked to a specific reason and vice versa with the positive ones, an inferential analysis was carried out. The relevance of the emotional factor and affective domain has been discussed elsewhere [42]. To this end, we crossed the category Kind of emotion (which could be Positive or Negative) with the category Reason for feeling (which could be Current knowledge content, Previous knowledge content, Method, Not answered or Others). Table 3 shows the results of such crossing data, according to a χ^2 hypothesis test. As can be observed, 34% of negative emotions can be related with current knowledge content. On the other hand,

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 31 October 2019 doi:10.20944/preprints201910.0363.v1

Peer-reviewed version available at *Educ. Sci.* **2019**, *9*, 297; doi:10.3390/educsci9040297

positive emotions are associated with methodology in a 73%. This is statistically significant (p-value 0.00) and a high value of contingency coefficient (0.505) is reached.

Table 3. Inferential analysis of Reasons for emotions and Kind of felt emotions.

	Reasons				
Kind of emotions (K)	**Current knowledge content**	**Method**	**Others**	**Previous knowledge content**	**N/A**
Negative (% inside K)	8(34.8%)	6(26.1%)	5(21.7%)	4(17.5%)	0(0%)
Positive (% inside K)	8(13.6%)	43(72.9%)	6(7.3%)	5(6.1%)	6(7.3%)

Secondly, the relationship between kind of emotion and student has been studied using χ^2 hypothesis test. There is no significant evidence to prove a relationship between the type of emotions and the student (1, 2, 3 or 4). This is consistent with the description of

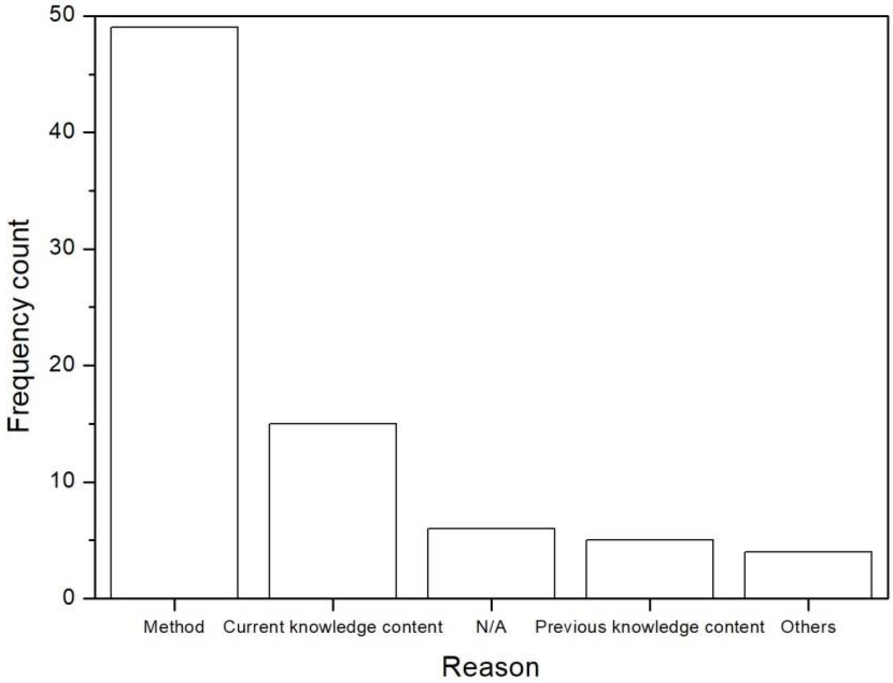

Figure **7.** Reasons attributed by the students to their own feelings. and could show there is not relationship between previous experience and emotions; and therefore, new methodologies cause positive emotions regardless of previous experience.

4. Conclusions

In this study we have studied an educational innovation experience combining gamification and flipped classroom. For the analysis of the experience, qualitative and quantitative techniques have been used, using interview and surveys.

The following conclusions can be drawn from the results of the study:

1. Students still find science difficult. However, the use of innovative techniques improves their perception and motivation towards this discipline.
2. Students have learned new techniques that they can use in their future professional activity. This aspect means that the innovations developed in the university context have a multiplier effect because they can affect future generations.

Although the experience has been developed in a small group of students (18), the results show that it would be interesting to be able to apply it, with appropriate adaptations, in larger groups. In future studies we will analyze the application of this technique in these groups.

Author Contributions: Conceptualization, F.Z.-P., J.S.-M., and L.E.-A.; methodology, F.Z.-P and J.S.-M..; formal analysis, F.Z.-P. and J.S.-M..; investigation, F.Z.-P., J.S.-M., and L.E.-A.; data curation, F.Z.-P. and J.S.-M..; writing—original draft preparation, F.Z.-P., .J.S.-M., and L.E.-A.; writing—review and editing, F.Z.-P.,J.S.-M., M.C.-S., and L.E.-A; visualization, F.Z.-P., J.S.-M., and M.C.-S.; funding acquisition, J.S.-M..

Funding: This work was partially supported by the Spanish Government (Economy and Competitiveness Ministry) under EDU2016-77007-R (AEI/FEDER, UE) project, IB16068 (Junta de Extremadura / Fondo Europeo de Desarrollo) as well as by the Regional Government of Extremadura (GR15009) and by the Researching Group DEPROFE, from University of Extremadura.

Acknowledgments: Authors are most grateful to the students from Didactics of Matter and Energy (Group 4, Primary Teacher Degree) and especially to those 4 that actively participated as interviewed subjects and due to the anonymity cannot be mentioned.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Román-Suero, S.; Sánchez-Martín, J.; Zamora-Polo, F. Opportunities given by final degree dissertations inside the EHEA to enhance ethical learning in technical education. *Eur. J. Eng. Educ.* **2013**, *38*, 149–158.

2. Sánchez-Martín, J.; Zamora-Polo, F.; Moreno-Losada, J.; Parejo-Ayuso, J.P. Innovative education tools for developing ethical skills in university science lessons. The case of the moral cross dilemma. *Ramon Llull J. Appl. Ethics* **2017**, 225–245.

3. Zamora-Polo, F.; Sánchez-Martín, J.; Corrales-Serrano, M.; Espejo-Antúnez, L. What Do University Students Know about Sustainable Development Goals? A Realistic Approach to the Reception of this UN Program Amongst the Youth Population. *Sustainability* **2019**, *11*, 3533.

4. Zamora-Polo, F.; Sánchez-Martín, J. Teaching for a Better World. Sustainability and Sustainable Development Goals in the Construction of a Change-Maker University. *Sustainability* **2019**, *11*, 4224.

5. Ríos, I.D.L.; Cazorla, A.; Díaz-Puente, J.M.; Yagüe, J.L. Project-based learning in engineering higher education: Two decades of teaching competences in real environments. In Proceedings of the Procedia - Social and Behavioral Sciences; 2010; Vol. 2, pp. 1368–1378.

6. Hargreaves, A. The Emotions of Teaching and Educational Change. *Extending Educ. Chang.* **2005**.

7. Hewitt, D.; Tarrant, S. *Innovative Teaching and Learning in Primary Schools*; SAGE, 2015; ISBN 1473917379.

8. Harvey, E. *Secondary education: perspectives, global issues and challenges*; Nova Science: New York, USA, 2016; Vol. 87;.

9. Christensen, C.M.; Eyring, H.J. *The Innovative University: Changing the DNA of Higher Education from the Inside Out*; John Wiley and Sons: Londons (United Kingdom), 2012; ISBN 9781118063484.

10. Abad, E.; Gil, J.; Suárez, P. A game-based educational method relying on student-generated questions. *Int. J. Eng. Educ.* **2017**, *33*, 1786–1797.

11. Zamora-Polo, F.; Martínez Sánchez-Cortés, M.; Reyes-Rodríguez, A.M.; García Sanz-Calcedo, J. Developing Project Managers' Transversal Competences Using Building Information Modeling. *Appl. Sci.* **2019**, *9*, 4016.

12. Jeong, J.S.; González-Gómez, D.; Cañada-Cañada, F.; Gallego-Picó, A.; Bravo, J.C. Effects of active learning methodologies on the students' emotions, self-efficacy beliefs and learning outcomes in a science distance learning course. *J. Technol. Sci. Educ.* **2019**, *9*, 217.

13. Jeong, J.; Cañada-Cañada, F.; González-Gómez, D. The Study of Flipped-Classroom for Pre-Service Science Teachers. *Educ. Sci.* **2018**, *8*, 163.

14. Zhang, J.; Xie, H.; Li, H. Project based learning with implementation planning for student engagement in BIM classes. *Int. J. Eng. Educ.* **2018**, *35*, 310–322.

15. Fried, R.L. *The passionate teacher: A practical guide*; Beacon Press, 2001; ISBN 0807031437.

16. Yowel, C. Primary schools are not a good place for testing new methodologies. *El Pais* 2017.

17. Sánchez-Martín, J.; Cañada-Cañada, F.; Dávila-Acedo, M.A. Just a game? Gamifying a general science class at university: Collaborative and competitive work implications. *Think. Ski. Creat.* **2017**, *26*, 51–59.

18. De-Marcos, L.; Domínguez, A.; Saenz-De-Navarrete, J.; Pagés, C. An empirical study comparing gamification and social networking on e-learning. *Comput. Educ.* **2014**, *75*, 82–91.

19. Zichermann, G.; Cunningham, C. *Gamification by design: Implementing game mechanics in web and mobile apps*; O'Reilly Media, Inc.: Sebastopol, California, 2011; ISBN 1449315399.

20. Buckley, P.; Doyle, E. Gamification and student motivation. *Interact. Learn. Environ.* **2014**, *24*, 1162–1175.

21. Koster, R. *Theory of fun for game design*; Paraglyph press: Scottsdale, Arizona, 2005; ISBN 1449363199.

22. González-Gómez, D.; Jeong, J.S.; Airado Rodríguez, D.; Cañada-Cañada, F. Performance and Perception in the Flipped Learning Model: An Initial Approach to Evaluate the Effectiveness of a New Teaching Methodology in a General Science Classroom. *J. Sci. Educ. Technol.* **2016**, *25*, 450–459.

23. Fidalgo-Blanco, A.; Martinez-Nuñez, M.; Borrás-Gene, O.; Sanchez-Medina, J.J. Micro flip teaching – An innovative model to promote the active involvement of students. *Comput. Human Behav.* **2017**, *72*, 713–723.

24. Medina, J.J. Brain rules: 12 principles for surviving and thriving at work, home, and school. Seattle, Wash 2008.

25. Novak, G.M.; Patterson, E.T.; Gavrin, A.D.; Christian, W. *Just-in-time teaching : blending active learning with web technology*; Prentice Hall series in educational innovation: Saddle River, 1999; ISBN 0130850349 (pbk.).

26. Brígido, M.; Borrachero, A.B.; Bermejo, M.L.; Mellado, V. Prospective primary teachers' self-efficacy

and emotions in science teaching. *Eur. J. Teach. Educ.* **2012**, *36*, 200–217.

27. Borrachero, A.B.; Brígido, M.; Gomez, R.; Bermejo, M.L.; Mellado, V. Emotions in prospective secondary teachers on the science learning and teaching process (Las emociones de los futuros profesores de secundaria sobre el aprendizaje y la enseñanza de las ciencias). *Int. J. Dev. Educ. Psicol.* **2011**, *23*, 521–530.

28. Sánchez-Martín, J.; Álvarez-Gragera, G.J.; Dávila-Acedo, M.A.; Mellado, V. What do K-12 students feel when dealing with technology and engineering issues? Gardner's multiple intelligence theory implications in technology lessons for motivating engineering vocations at Spanish Secondary School. *Eur. J. Eng. Educ.* **2017**, *42*, 1330–1343.

29. Sánchez-Martin, J.; Alvarez-Gragera, G.J.; Davila-Acedo, M.A.; Mellado, V. Teaching technology: From knowing to feeling enhancing emotional and content acquisition performance through Gardner's Multiple Intelligences Theory in technology and design lessons. *J. Technol. Sci. Educ.* **2017**, *7*, 58.

30. Mellado, V.; Borrachero, A.B.; Brígido, M.; Melo, L.V.; Dávila, M.A.; Cañada, F.; Conde, M.C.; Costillo, E.; Cubero, J.; Esteban, R.; et al. Emotions in science teaching | Las emociones en la enseñanza de las ciencias. *Enseñanza las Ciencias* **2014**, *32*, 11–36.

31. Brígido, M.; Couso, D.; Gutiérrez, C.; Mellado, V. The emotions about teaching and learning science: a study of prospective primary teachers in three Spanish universities. *J. Balt. Sci. Educ.* **2013**, *12*.

32. Jeong, J.S.; González-Gómez, D.; Cañada-Cañada, F. Students' Perceptions and Emotions Toward Learning in a Flipped General Science Classroom. *J. Sci. Educ. Technol.* **2016**, *25*, 747–758.

33. Dávila Acedo, M.A.; Borrachero Cortés, A.B.; Cañada-Cañada, F.; Martinez Borreguero, G.; Sánchez Martín, J. Evolution of the emotions experienced by prospective primary teachers, focused on didactics of matter and energy. *Eureka sobre Enseñanza y Divulg. las Ciencias* **2015**, *12*, 550–564.

34. Patton, M.Q. *Qualitative evaluation and research methods, 2nd ed.*; 1990; ISBN 0-8039-3779-2 (Hardcover).

35. SPSS *SPSS 14.0 Developer's guide*; IBM: Chicago, Illinois (USA), 2005;

36. Borrego, C.; Fernández, C.; Blanes, I.; Robles, S. Room escape at class: Escape games activities to facilitate the motivation and learning in computer science. *J. Technol. Sci. Educ. Vol 7, No 2 9th Int. Conf. Univ. Teach. Innov. Learn. Teach. Innov. impactsDO - 10.3926/jotse.247* **2017**.

37. Clarke, S.; Arnab, S.; Keegan, H.; Morini, L.; Wood, O. Escaped: Adapting live-action, interactive games to support higher education teaching and learning practices. In Proceedings of the Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics); 2016.

38. Eukel, H.N.; Frenzel, J.E.; Cernusca, D. Educational Gaming for Pharmacy Students - Design and Evaluation of a Diabetes-themed Escape Room. *Am. J. Pharm. Educ.* **2017**, *81*, 6265.

39. Bujacz, A.; Dunne, S.; Fink, D.; Gatej, A.R.; Karlsson, E.; Ruberti, V.; Wronska, M.K. Why do we enjoy

Peer-reviewed version available at *Educ. Sci.* **2019**, *9*, 297; doi:10.3390/educsci9040297

creative tasks? Results from a multigroup randomized controlled study. *Think. Ski. Creat.* **2016**, *19*, 188–197.

40. Suwal, S.; Singh, V. Assessing students' sentiments towards the use of a Building Information Modelling (BIM) learning platform in a construction project management course. *Eur. J. Eng. Educ.* **2018**, *43*, 492–506.

41. Yang, Y.; Asaad, Y.; Dwivedi, Y. Examining the impact of gamification on intention of engagement and brand attitude in the marketing context. *Comput. Human Behav.* **2017**, *73*, 459–469.

42. Sánchez-Martin, J.; Cañada-Cañada, F.; Dávila-Acedo, M.A. Emotional responses to innovative Science teaching methods: Acquiring emotional data in a General Science teacher education class. *J. Technol. Sci. Educ.* **2018**, *8*, 346.