Article

Emotional performance of a low-cost eco-friendly Project Based Learning methodology for science education: an approach in prospective teachers.

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Abstract: Enhancing the emotional dimension of prospective teachers in science subjects - what has become increasingly important in recent decades - is higher education stuff responsibility. The implementation of active methodologies could modify the traditional student-teacher roles that are encouraged by the educational policies implemented in the Bologna Process and at the same time it is possible to promote sustainability knowledge, attitudes and behavior required by UNESCO. The principal aim of this work is to describe a Project Based Learning methodology with a transversal sustainability approach (low-cost and eco-friendly) and to introduce it as potential resource for the emotional and cognitive improvement of 19 prospective primary teachers enrolled in a scientific subject. This is a qualitative study in the context of a research line focused on Higher Education for Sustainable Development. A questionnaire was designed and filled by the students at two different times, before and after implementation of the activity. The initial feedback from students was surprisingly enthusiastic by the fact that they were working with rockets, despite of this is not a common emotion in the science field. The results show the emotional improvement of prospective teachers after the implementation. It is concluded that a correct science education with sustainable approach is necessary during the training of teachers taking into account their emotional dimension and the social repercussion due to the future transmission.

Keywords: project-based learning; scientific education; preservice primary teacher; emotions; active methodologies; higher education for sustainable development

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1. Introduction

The concern that inspires us to carry out this research is the conviction of the need for educate a scientifically competent citizen, who is able of making decision and adapting to an irremediably scientific-technological world in an environmental crisis. We live in a context of over-information, where we have in the precise instant all information we want, but also disinformation and misinformation [1]. Scientific knowledge helps us to position ourselves in the world with a critical eye. In recent times, several anti-science movements have emerged, such as "Flat-Earthers"[2], or climate change deniers [3]. These developments only reinforce the demand for adequate science education including environmental awareness. Higher Education is essential for the social, economic and cultural development of society as it not only provides academic knowledge but also enhances the individual dimensions that are necessary for the basis of a civilized society [4].

We present a research made with prospective Primary teachers in a general science subject analysing the emotions reported before and after the implementation of a Project-Based Learning (PBL) methodology. PBL places the learner in the focus as the builder of his or her own learning, being able to solve certain problems or challenges autonomously [5] while teachers provide the necessary supervision and support [6]. We do it in the context of a research line focused on Higher Education for Sustainable Development (HESD) what has been encouraged by UNESCO through different programs [7] and at this time with Agenda 2030 [8]. Higher education has a decisive role training responsible citizens. Sustainable practices and policies should be developed to promote green attitudes at University and higher education institutions, as well as to favor the acquisition of sustainable management models [9] to generate a sustainable way of learners' thinking.

First, in the introduction, the authors reflect on how teaching sciences in higher education to a non-scientific audience [10] according to the scientific method. In detail, to facilitate the future reply, a step-by-step description of the methodology is given. The qualitative analysis of the emotional dimension of prospective teachers and the results are shown. At the end, a discussion - authors compare with other research that have implemented PBL and other active methodologies at higher education-, some limitations - since it is a case study-, and final considerations with social implications are added. In this paper, the authors encourage the implementation of active methodologies for HESD, in particular at Primary Education Degree.

The main objective of this research was to describe a PBL experience and to assess the student's perceptions and emotions when a PBL setting is followed as instruction methodology. The study was conducted in a general science course, sophomore of the Primary Education bachelor's degree in the Faculty of Education of the University of Extremadura (Spain) during the course 2018/2019.

2. Background

The background section is structured in four sub-sections, the first one (a) is to introduce the implications and the need for scientific literacy at Primary Education Degree in the context of 2030 Agenda for Sustainable Development Goals which is what the HESD requires and demands. The second part (b) is concerning to the emotional dimension in education. We then (c) transfer this to the Primary Education Degree, and we expose an overview of the particularities we find in these students, some considerations, and difficulties, with an emphasis on their emotional dimension. Finally, (d) we describe the methodology implemented -PBL- analyzed from a point of view of the "nature of science" and the most suitable way we found for teaching science according to the literature review. The authors reflect on the need for a methodological change due to the future teacher in training practice repercussion and the requirement of a correct teaching of science. This is achieved by *hands-on* activities based on the scientific method that would help to reverse the negative past experiences of prospective teachers with a sustainable approach.

2.1. Implications and need for Scientific Literacy at Primary Education Degree

In the undoubtedly scientific and technological societies we live in, with major environmental challenges to be solved by future generations, scientific literacy is necessary to enable citizens to participate effectively in the real world. Scientific literacy includes (a) intellectual aspects, referring to conceptual knowledge, explanations and analysis of the interactions between science, technology and society; (b) attitudinal and behavioral aspects, consisting of being able to apply scientific research, knowing how to communicate and showing curiosity about the world; (c) social and ethical aspects, situating science and technology as human constructs, recognizing the strengths and limitations of science and taking responsible actions; (d) and interdisciplinary aspects, connecting science, arts, technology, history, humanities, economics, and all the rest of global issues [11]. To reach that goal it is necessary to know prospective teachers' beliefs, attitudes and behavior towards science and towards science learning [12].

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The current planetary emergency situation we are living [13] is increasing its importance in social media and in every living context, to convey this message to future generations is urgent and crucial. The present is endangering; some alarms show that our system is unsustainable (people are dying, our aggressive consumption patterns, the environmental degradation…) [14] and global warming has increased global economic inequality [15]. However, an education that ignores the affective dimensions of learners is also unsustainable. Educating in sustainability consciousness allows the development of correct attitudes and behaviors to protect the Earth and reduce pollution or climate change [16,17], for this, we find that institutions (and all stakeholders) have to combine the current concern for the environment and what is explicitly required by 2030 Agenda [8] (teaching for Sustainability) and, on the other hand, adapt to the new contexts of education.

Education has a key role in the development of societies, and educators act as "change agents" to achieve sustainability [18,19]. Higher institutions are undergoing major transformation due to the internationalization and globalization of education, the ambiguity and the change of the space and time conceptions, new paradigms of knowledge production, the transformation of societies and science and the inclusion of the new technologies [20]. Technological development in recent decades has led to changes in the way we teach and learn. Higher education has also been affected by technology [21] which is a major challenge for universities [22]. Some adaptations include, in Europe, the implementation of Bologna Process [23], which requires students and teacher to adapt to a new "competences" model that is reflected in new subjects syllabus [24–26], transferring the central role of teachers to student-centered teaching [27].

International assessment tests such as PISA [28] and TIMMS [29] revealed that science teaching and learning is at a critical juncture. These studies summarized the student's science literacy level of OECD countries, the level of performance of Spanish students in mathematics and science subjects is lower than the average level of OECD countries. In the present work, we have chosen the scientific method for teaching science in the Primary Education Degree, which trains and qualifies prospective teachers for the profession. In primary school, science is integrated in all courses. Despite the fact that during their instruction, the official curriculum of Primary Teachers Degree preservice teachers at the University of Extremadura (Spain) only has to take three subjects (representing 18 ECTS) [30]. The prospective teacher's profile has been defined in previous researches [10,31]. Generally, they tend to have a low self-efficacy perception, and have serious difficulties in understanding the importance of scientific knowledge. Prospective teachers have a low motivation and often experience negative emotions towards sciences (such as anxiety, boredom, or rejection) [32]. They often lack scientific characteristic such as curiosity, perplexity, or surprise. Prospective teachers often come from upper secondary studies related to social sciences or arts, which implies a low scientific knowledge background. Moreover, the scientific literature shows that prospective teachers generally do not like science, they feel uncomfortable when they have to teach it and think it is difficult to learn and boring [33]. Marcos-Merino, Corbacho-Cuello and Hernández-Barco [34] described the sustainability consciousness of a Spanish prospective teachers sample, including knowledge, attitudes and behavior in the three dimensions of sustainable development (environmental, social and economic), their results suggested that prospective teachers despite having high levels of sustainability attitudes, do not report high levels of sustainability behavior. Authors manifest the need to teach about sustainability in the initial training of teachers to improve not only knowledge but also modify their behavior.

Why not using science for science teaching? The authors think that when prospective teachers learn science, they should do so by following the same process as the construction of science: making observations, asking questions, planning, conducting investigations, thinking critically and logically, communicating scientific arguments… Minds so trained will contribute to the improvement of society and to the scientific development [35]. Understanding the Nature of Science would help the development of scientific literacy, where knowledge is not the main focus but personal attributes and social development [11]. This would help them to enjoy the creation of science and to live new experiences

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that place them in the scientific role. Bellová, Melicherčíková and Tomčík [36] went into how to increase the effectiveness of teaching the natural sciences subjects, and revealed that understanding how science functions involves a synthesis of *content* -knowledge of the facts, concepts, ideas and theories-, *procedural* -the procedures that scientist use to establish scientific knowledge- and *epistemic* knowledge -that refer to the understanding of the role of specific constructs and defining features which are essential to the process of knowledge building in science-. The challenge is to awaken positive emotions and initiate some of these scientific principles during prospective teachers training and generate prospective teachers who know how to do science.

2.2. Emotions in education process

The interest in emotions and what they generate in human behaviour is practically inherent to human existence. In the civilizations of ancient Greece, philosophical theories and metaphors were put forward that reflected on the emotional aspect of the human being [37]. Since their origins, emotions and mind have been at odds with each other and at opposite poles [38]. However, emotions and the cognitive dimension have been considered independently, considering aspects such as memory, learning and attention on the one hand, and on the other hand, the emotional and cognitive response [39–41].

Nowadays, the association between the affective and cognitive dimensions in human beings is undeniable [42] and educational processes are replete with affects. Emotions influence students' learning and achievement [43,44] as they help to direct attention, which is a requirement for learning [41]. Emotional events in the classroom help to establish or onbstaculate concepts in the memory [45].

It is possible to find numerous classifications and taxonomies of emotions in the literature. Darwin started the biological study of emotions [46], he described and compared diverse universal facial expressions. Many authors as Ekman [47], Damasio [48] or Goleman [49] have tried to establish classifications of basics emotions. However, there is still no established categorization. In this work, we use the definition of emotion proposed by Bisquerra [50]:

Emotion is a complex state of an organism characterized by an excitation or perturbation that predisposes to an organized response. Emotions are generated in response to an external or internal event (Bisquerra, 2003, p. 12).

And we decided to follow the classification used by Dávila-Acedo et al. [32], based on that proposed by Fernández-Abascal et al. [51], in positive: confidence, enthusiasm, fun, joy, satisfaction and surprise; and negative: anxiety, boredom, fear, nervousness, rejection and worry. According to this classification positive emotions are those that ensure well-being, but the fact of classifying emotions into positive and negative has no connotation of "good" and "bad": emotions increase evolutionary fitness for the individual [52].

Robert Plutchik, following an evolutionary perspective, affirm that feeling states tend to be followed by impulses to action: emotion is a chain of events and part of a social regulation process [52]. In order to construct a model of the affective system, Díaz and Flores [53] gathered a selected group of terms into sets of related ideas, authors classified emotions on two axes of coordination: pleasant-unpleasant emotions on the vertical axis, and the opposite relaxation-emotion axis on the horizontal axis. Therefore, there are emotions that incite us to act, while others paralyze us [40]. Within our selection, the emotions classified as exciting (and thus promoting action) are fun, enthusiasm, joy, nervousness, surprise, anxiety and worry [54]. The opposites (paralyzing) are boredom, confidence, rejection and fear.

2.3. Project Based Learning for science education

Traditionally, science lessons have been taught through passive methodologies, in which the lecture has the main role and students only receive information [55]. The request for integration of the model competences brought with it a didactic and pedagogical challenge characterized by a constructivist understanding of education, focused on empowering students to address complex problems and future challenges (diverse conditions involving a multidimensional approach and immersion of different disciplines) [56].

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Learning is an integrative and constructivist progress, not just receptive. It is highly stimulating to provide students with new opportunities and conditions (science, problems, activities) that help them to actively participate in the classroom by linking the content to their real life.

In fact, there are several and multidisciplinary tools available and numerous pedagogical instruments that help to make science lessons more comprehensible while students improve other skills and competences [57]. In this paper, we present PBL as a methodology to teach science successfully, oriented towards self-learning and aimed at empowering prospective teachers. In the figure 1, we present the steps to develop a PBL [58]:

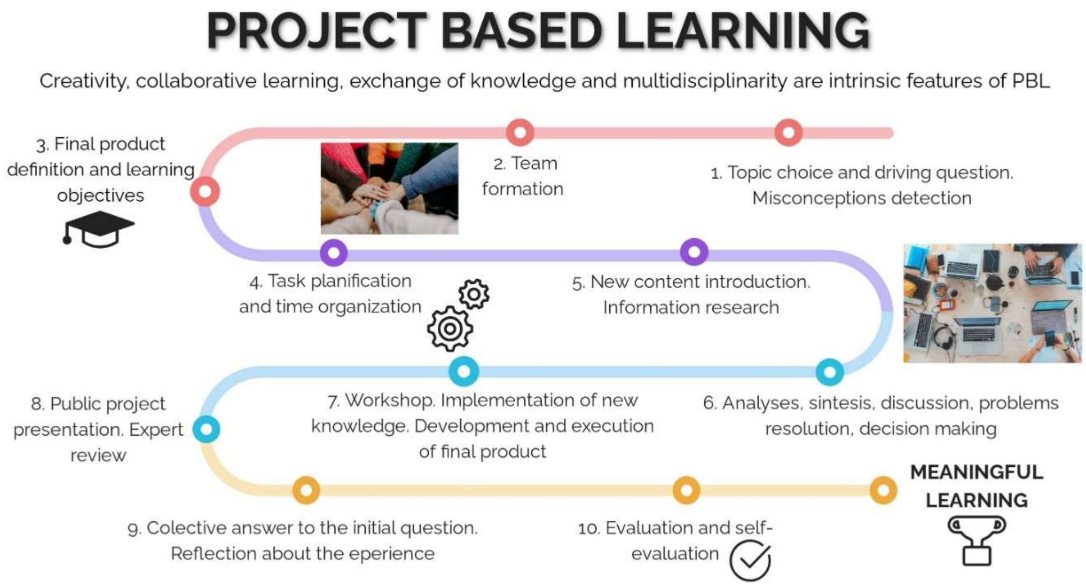

Figure 1. Step of Project Based Learning. Own elaboration. Source [58].

PBL is a pedagogical methodology that places the learner in the focus as the builder of his or her own learning, being able to solve certain problems or challenges autonomously [5]. Teachers provide the necessary supervision and support [6]. Some advantages are (1) it enables meaningful learning, helping to modifies previous knowledge, (2) it is extremely versatile, easily applicable to any content and subject, (3) it stimulates autonomous learning, improving decision-making and increasing responsibility, (4) it is motivating and joyful, setting challenges that arouse curiosity, (5) can be used to prepare them for future problems, placing them in real contexts, (6) develops digital competences, developing web searching and information selection in different languages and formats [59].

There are many references about the benefits of using active learning methodologies in science teaching [31,60–63]. However, there still exists a gap in characterizing how these methodologies, different from traditional exclusively orally-based lessons, affect the learning experience [10,31,60]. A few bunch of authors have already pointed out the main role the methodology has on the learning experience, rather than other factors such as the content itself [64] or the academic background [65].

When designing a good PBL, these emotional considerations have to be taken into account, so the entire didactic proposal is not only a matter of cognitive learning, but also an emotional and behavioral changing learning[1].

The key to begin generating changes in the teaching practice may be to know how to activate emotions in the classroom through methodologies such as PBL, and to take advantage of current knowledge about the brain within the constructivist paradigm so as to lead to more meaningful learning [66,67].

[1] See: CLIL for Young European Citizens. Project No. 2019-1-it02-ka201-063222

2.4. The activity for HESD: Hydro propulsion. Historical context and scientific content

Humans are born inquirers. Astronomy arouses public interest [68]. The investigation of the universe has always been fascinating for humans, many children dream of becoming astronauts, space is attractive and exciting to study. Satellites, galaxies, and planets are very motivating for students. The National Aeronautics and Space Administration (NASA) has created a Rockets Educator's Guide [69]. In it we can see that all rockets - whether they are the biggest ones or a small model- work according to the same laws, so by understanding and employing these rules all rockets could function correctly as expected.

The rocket development represents the human curiosity (basic human trait that has ensured both our survival as species and our continuous cultural evolution [35]) and the need to explore and discover through experimentation. We wanted to take advantage of this so we included the design of a rocket for the subject of Didactic of matter and Energy whose content is related to (1) the current challenges of science education (interdisciplinarity and didactic projecting in relation to science, technology and society), (2) learning to teach sciences in Primary Education throughout different methodologies (inquired-based learning, problem resolution, practical approach or project based learning…) and (3) science content in primary education. This subject is taught in a sustainability transversality-oriented way in order to break down the barriers between life and school, and empower learners to take decisions and to promote sensible behaviors for ecological integrity, economic viability and a fair society, for current and future generation. UNESCO has developed a guide with several competencies for sustainability that HESD should work to achieve, including (a) systems thinking, (b) anticipatory, (c) collaboration, (d) critical thinking, (e) self-awareness and (f) integrated problem-solving competency [70]. The aim of this project was to unify them in the building of water rockets out of recycled soft plastic drink bottles, and students would verify that the bottles are able to fly over a hundred meters. The rocket building comprises two parts: the rocket itself, which consists of a recycled bottle part filled with water and pressurized with compressed air supplied by a hand pump and a specially designed launch pad is required for holding the rocket while it is being pressurized. When the precise pressure is attained, the rocket is launched by liberating from the launch base [69]. The launch base is constructed with recycled materials for an eco-friendly and low-cost hydro-rocket, so environmental consciousness is promoted.

Other subjects can be worked on through this intervention, and it becomes an interdisciplinary learning ST^{2}EAM (Science, Technology, Transformative learning, Engineering, Arts, and Mathematics) which provides prospective teacher with fruitful educational experiences that help them to develop knowledge and skills that surpass disciplinary boundaries required to solve today's challenges [71,72]. For example:

-Philosophy and history of science. The real world can be studied from two different perspectives: a microscopic one (atomic or molecular scale) offering a discontinuous nature, and a macroscopic one (including continuous material systems detected by our senses). Epistemologies, ontologies, the scientific method and the integration of ST^{2}EAM disciplines can be taught through the hydrojet intervention. The origin of mechanical physics -kinematic, statics, and dynamics- which began with Archimedes; then how Kepler and Galileo initiated mechanics as an experimental science and finally Newton's lows of motion [73]. Newton summarized all rocket science in three scientific laws published in "*Philosophiae Naturalis Principia Mathematica*" [74].

-Modern and contemporary history and the paradigm shift in scientific thinking. The world's first artificial satellite was launched on October 4, 1957, it was Sputnik I, which led to a reform in science teaching [75]. There are many recent anecdotes linking scientific and economic development: the race for the space for being the first colonizer of the moon, or the global Cold War between the United States and the Soviet Union that brought the world to a standstill.

-Bioethics and the way science is influenced by morality and economy can also provide food for thought. Months after the Sputnik launch, the United States also successfully

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launched Explorer 1 on January 31, 1958. And finally, on July 20, 1969, it was the first time in history that humans explored other surfaces, in this case the moon by Neil Armstrong. But science does not always bring good ends: World War I and World War II has fostered the development of science and not for the benefit of humanity. Ethical issues can be raised here.

-Art and the development of aesthetic sense. Besides the undoubtedly technological and scientific component of the intervention, the hydrojet design is also assessed. Students who found science learning uninteresting or boring for them, by using art can find the attractions of physics along with its difficulties [76]. Izadi [76] reflects on how to guide students to learn science from their own creativity in art, suggesting that teachers can design inquiry workshops focuses on developing students' problem-solving skills and then students, using their creativity in art, provide solutions.

-Mathematics and technology. In science, is quite common to make measurements used in a calculation to obtain a necessary value. A recurring story is the 1998 destruction of "Mars Climate Orbiter" due to a mistake in unit conversion. It is very important that prospective teachers have a good knowledge of unit conversion and the metrical system, which should be taught in Primary Education. With this project, prospective teachers are introduced to the study of scientific method and begin to manipulate laboratory material and unit conversion. The creation of a rocket and its basis offers the inclusion of technology in the project.

The entire project must be carried out involving aspects related to environmental awareness. The fact of choosing a hydrojet (instead of a LPG or combustion jet) gives the teacher argue about the need for eco-friendly technologies. And since we are working with recycled materials, concepts such as 0-residue, circular economy (science) or 3R's can be also included in the lesson.

3. Materials and Methods

3.1. Sample

The sample consist of 19 pre-service Primary teachers (78,9 % female). Regarding their background studies, 84 % of participants studied a modality of Humanities, Social Sciences or Arts in Upper-Secondary Education, whereas 16 % of them attend a Science, Health, Sciences or Technology itinerary to access to university studies. This sample has been intentionally chosen, not randomly, from the population of Primary teachers in training, all of them enrolled in a subject called Didactic of Matter and Energy. Participants were informed about been part of an educational research, the duration, the process, and the anonymity of their data. By the fact of being a human investigation which involves data collection from individuals, all actions made were in agreement with the ethical standards with the 1964 Helsinki declaration. Written informed consent was obtained from participants and the study was authenticated conforming the ethical committee (Comisión de Bioética y Bioseguridad, Universidad de Extremadura). All the information about bioethics and ethics in research activity at University of Extremadura can be retrieved from [77].

3.2. Survey design and data collection

For data collection we decided to draft a questionnaire specifically for this study (see Appendix). We used Google Form to manage the data instantly and easily. The design was inspired by previous research with a similar sample [32]. The questionnaire consisted of two parts, the first one with socio-demographic data (gender and background studies), and the second referring to the emotions they expected to feel during the rocket fabrication. This section is composed of a list of twelve emotions (six positive and six negative) and they have to answer if they feel or not and explain why. In the literature review one finds several emotions classification and taxonomies. Paul Ekman [47] determines six basic emotions: anger, dislike, frightened, joy, sadness and surprise. Other authors, as Damásio [48], Goleman [49] or Bisquerra [78] have also try to establish a categorization of emotions but is a hard work [79]. The emotions selected for the present study belongs to

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a classification used by Dávila-Acedo et al. [32], based on that proposal by Fernández-Abascal, Martín, and Dominguez [51] which consist on (6) positives emotions: confidence, enthusiasm, fun, joy, satisfaction and surprise, and (6) negatives emotions: anxiety, boredom, fear, nervousness, rejection and worry. The questionnaire was provided on two times: just before and after the PBL implementation.

Recognizing and identifying student's emotions is the first step to intervene. Before the questionnaire was provided, students were informed about the goals of the research, duration, procedure and anonymity of their data. Participation was voluntary and all participants provided verbal informed consent before data collection. The researchers were always present during the survey realization.

3.3. Data Process and Analysis

A descriptive analysis was selected as the most appropriate way to characterize, describe, and draw conclusions from the sample data, based on the content analysis proposed by Bardin [80], which consist of a technique for interpreting text analysed in a systematic, objective, replicable and valid way. The comments provided by the participants to justify the response given to each emotion were transcribed and analyzed. Both explicit (what prospective teachers write) and latent data (what it says unintentionally) make sense and are captured within a context. We wanted to take advantage of a small group of participants to aid the qualitative analyses.

3.4. Material and resources for PBL implementation

The prospective teachers are asked to bring all the elements they want to use: for the water rocket, two empty and clean 2-liter and 1,5 liters' soft plastic drink bottles are needed, at least two of different capacities (that it is interesting for student trying and experimenting with different measures), a cork stopper, a meter stick and bicycle pump. It is also recommended eye protection. Some resources are provided for the launch platform construction: a tile, duct tape or scissors. Other materials for holding device, such as woods, are recommended. A launch record sheet is provided, and they should bring their own computer, to record each launch. Water is available on site.

4. Results

4.1. Project-Based Learning description

The experience was developed in a course called Didactic of Matter and Energy. This course is taught as part of the Primary Teacher Degree, specifically in the sophomore year (third semester, eight semesters in all) and is compulsory. This subject requires 150 h of students' personal work (6 European Credit Transfer System), which are divided into large group (45 h) and small group (15 h) learning activities, the rest (90 h) are autonomous learning. It is the first science subject that prospective teachers receive at the beginning of their university studies.

The PBL activity has been implemented in small group activities, using 9 hours (three session of three hours each, spread over three weeks) in the context of a gamified science subject therefore winners were awarded. The project consists of a rocket launching competition designed and constructed by prospective teachers using recycled materials.

4.1.1.-. First session: warm-up, organization and information research time

At the beginning, the project was introduced; students were informed that they were going to build a rocket. At this point, the questionnaire was provided to know what emotions they felt towards the rocket fabrication. Then all stages, activities, and a chronological process of what they were going to do in all sessions were presented. The students organized themselves into teams of three or four members. The students documented themselves and gave the general direction of the work. They designed the experimentation planning and decided on the rocket' model they were going to build based on a research (Youtube, personal blogs or scientific articles). They decided on the kind of launch

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platform, including the drawing or pictures they found. They researched the best combination of variables to win the competition. They designed a sequence of experiments to obtain criteria to decide which values of the variables would be determinants: how much water, what kind of bottles or the angle of inclination of the base. They documented all steps in an essay.

4.1.2.-. Second session: problem resolution and decision making

During the second session, each team built their rocket, the launch site and they started experimentation. The manufacturing was done in the laboratory, and the launches were done outside. There are different tasks, one member of the group acts as the launcher, another has to count the time and measure the launch distance, document and send back the rocket to the launch site for the next flight. The students repeated the launches over and over, trying different combination of the variables. The experimental variable was the launch angle, and the students compared the launch angle with the distance travelled by the rocket. The distances travelled were recorded and averaged according to the angle of throw and the volume of water on the data collection sheet. They did not have to complete a minimum or maximum number of launches, but rather determine the best launch angle to obtain the best distance from the launch site. For high launch angles, the arc is steep and for low angles it is wide. The wind becomes an uncontrolled variable. If student work carefully, they observe that their furthest flights came from forty-five degrees' angle launches.

4.1.3.-. Third session: the rocket launching competition

Finally, the day of the competition. They had time to make the last decisions or to think about how to improve the model they had initially chosen. The final challenge took place on a football field and a team of three external referees assessed the rocket launches. For the competition, two different aspects were measured.

On the one hand, the rockets were launched in a straight line, the flight time was measured, the one that takes the longest to fall was considered to be the highest (neglecting air currents), and the rocket returned to the launch site. Thus, the highest rocket was awarded.

On the other hand, the students compared the launch angle with the distance at which the hydro rocket touches the ground from the launch site, so it was also measured how far the rocket reaches the launch site. This depends on four things: the launch angle (less than 90 degrees), which is the independent variable; the acceleration of gravity, which will be the same for all launches so gravity can be ignored; the initial velocity, which students didn't know it; and atmospheric drag, which affects the flight time. The furthest one was also awarded. After the challenge, the questionnaire was again provided to be filled in. In Youtube you can find the rocket launching competition [81].

4.1.4.- Low-cost & hydro rocket assessment

The fabrication of the hydro rocket involves investigations of the natural world, and several components were assessed. All students were able to carry out the experience, what included the comprehension of the scientific processes that involves the hydro rocket construction: measurement (water, ancles, distance, time…), observation, data collection and management, experimental design, problem solving, scientific content, skills development… Initially, a diagnostic assessment was carried out to determine the prospective teachers' knowledge and understanding of the subject, classroom discussions and informal observations were conducted, and also an emotional pre-test were carried out.

Throughout the whole experience and during all the sessions, students were assessed of a formative way, helping and guiding them day-to-day. Individual and group development were supervised. Teachers who have participated in the experience looked carefully at prospective teachers' work.

After the rocket launched competition, students draw valid conclusion that were delivered in a report and they recognize regularities in nature, including concepts and content scientific knowledge.

The final assessment of the entire experience was carried out by merging three concomitant outputs:

a) The most relevant one was the Final Report each team had to upload to the web, so they could be shared by all the students. This document consisted of a preliminary theoretical background (designing the rocket), an experimental sequence (optimizing operational variables) and the final description of the rocket. This Report should include textual documents, mathematical procedures and data process and graphical/audiovisual evidences of the whole experience.
b) An observational diary was also carried out in order to assess periodically the students about their performance. So qualitative comments are daily provided, once the number of students was not very high.
c) Finally, contents (cognitive ones) were included in the regular final exam, which is perceptive for passing the subject. Concepts as Newton's Third Law, Pressure, Potential Energy or Free Fall were part of such evaluation proof.

4.2.- Analysis of emotional development

In this section, an analysis of positive and negative emotions will first be made, positive emotions will be shown, and then negative emotions will be shown. Rocket building is an activity that engage students. When the teachers presented this experience to the prospective teachers, they all reacted quite excited and surprised. Some of their comments aloud were related to the impossibility of achieving it. Their self-efficacy was quite low. They didn't feel prepared for rocket fabrication. Nevertheless, the percentage of positive emotions was quite high. The results of the positive emotions of pre-test and post-test are shown in table 1.

Table 1. Percentages of positive emotions selected by students (the percentage of "No" is omitted for been obviously) in the pre-test and post-test.

	Pre-test	Post-test
Positive emotions	**Yes**	**Yes**
Confidence	68.4	60
Enthusiasm	78.9	90
Fun	94.7	100
Joy	89.5	100
Satisfaction	89.5	80
Surprise	84.2	100

Now, a brief description of what we have found in the responses of questionnaire will be done. The following information have been extracted from the own discourses of prospective teachers and their responses following the Bardin's technique [80].

Confidence

When we asked about the degree of confidence they felt, the students who answered "yes" (68.4%), referred to the internal aspects (high expectations of themselves solving the project) and to the external factors which were (a) the teacher and the methodology, (b) the project itself (well structured, fun and new learnings). Students who reported not feeling confident indicated that they didn't feel competent, felt insecure and though that making the rocket would be difficult.

After the implementation, the percentages of students who affirmed they felt confident were lower. The students who responded affirmatively (60%) commented that their confidence increased and improved with the launches and that they were confident that they could perform the activities. On the other hand, students who didn't feel confident because they were afraid and didn't know how to do it.

Enthusiasm

Despite being a project that includes many enthusiastic dimensions, more than 20% of students stated that they did not feel enthusiasm before the project. The students stated that "*they had to do it as a must*". The rest of the student mentioned that they were enthusiastic about learning new things, about doing "an experiment" that they had never done before, and that they liked it.

After implementation, the enthusiasm increased and they said that they were exciting by the fact of being creating a hydro rocket, and because every single launch was different, and they wanted to see how far it could go.

Fun

At the beginning, 94.7% of students said that they had because it was a new methodology and an innovative experience to share with their peers. They thought that the experience was attractive, striking and that it would be fun. Some of them stated that they liked the subject, and the experimental methodology to understand how the world around us works.

After the implementation, 100% of students said that they had fun during the process of the rocket fabrication, that it was an interesting project, and they laughed a lot with their classmates.

Joy

In the open responses, when we asked about "joy" the prospective teachers talked about being excited about (a) having done new things (different, never done before), (b) having used the PBL methodology (intriguing, innovative, interesting), (c) new learnings, (d) challenging (e) and because "rockets are cool". Only two students responded that they did not feel joy, justifying themselves by saying that:

"*I'm bad at chemistry and everything related to it*" and "*I think it is going to be quite difficult for me*".

After the implementation, 100% of students stated that they felt joy. Their answers focused on the launches, they felt joy when they were testing the rocket, it was a challenge, and a new methodology that has exceeded their expectations.

Satisfaction

Students showed high values (89.5%), all comments were based only on the satisfaction they would feel in completing the task, doing a good job and learning.

After the implementation, satisfaction decreases. Those students who didn't feel satisfaction are the ones who didn't win any prizes, or the rocket didn't launch well. The students who said they felt satisfaction said that they had given their best and that gave them satisfaction.

Surprise

Finally, regarding surprise, they answered that they were surprised because they did not know what they were going to do and because of the expectation of destroying and modifying previous knowledge that was not correct.

After the implementation, all students felt surprise during the PBL process. They confessed that at the beginning they felt afraid, but they were surprised by the good organization of the group.

Concerning the negative emotions, the percentages before and after implementation are shown in table 2.

Table 2. Percentages of negative emotions selected by students (the percentage of "No" is omitted for been obviously) in the pre-test and post-test.

	Pre-test	**Post-test**
Negative emotion	**Yes**	**Yes**
Anxiety	57.9	20
Boredom	10.5	20
Fear	63.2	40
Nervousness	63.2	70
Rejection	10.5	0
Worry	47.4	60

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Anxiety

42.1% of students stated that they felt anxious before the project, their answers referred to (a) the possible difficulties they thought might arise, (b) being something new and unknown, (c) the limited time they had and (d) there was one student who stated that she always feels anxious during science learning. However, we see that after the rocket fabrication, anxiety decreases by up to 20%.

"I take it slowly because I knew that everything was well organized."

Boredom

Almost no students answered that the experience made them feel bored, they thought that the project was enjoyable and fun, and that it would help them in their future with their upcoming students. However, after the implementation boredom increases to 20%, and they argued that the repetition of the launches made the experience boring.

Fear

The students who answered yes argued that they felt they would not be able to build the rocket no matter how hard they tried. We did not get any justification for the students who said they didn't feel fear during the rocket fabrication.

After the implementation, the fear decreases o 40%. One student stated that she did not feel fear because *"I knew that no matter what happened, I had tried."*

Nervousness

The answers were closely related to the previous emotion: fear. More than a half of the student said they were nervous prior to the launch of the expectation that the project generated, the time limitation, difficulties that might arise, poor results and if the rocket did not work well.

After the implementation the nervousness increased, and the responses were about competition and the pressure of the launch challenge.

Rejection

The rejection values reported prior to implementation are quite low. Some students justified that they felt rejection because of possible difficulties that could arise. After the implementation, this emotion was not selected by any student.

"Because the project was motivating and because we were working with a different methodology."

Worry

Finally, in terms of worry, more than half of the students stated that they were worried about the stress of doing well, about some difficulties that might arise or about not getting it right. After the implementation, worry increased to 60% and prospective teachers affirmed they felt worried about the rocket competition and about not getting the rocket launch.

Regarding the positive emotions we see that from the beginning, the scores were quite high (all above 60%), but most of them have even increased to 100% (such as fun, joy and surprise). However, two positive emotions have decreased, such as confidence and satisfaction. In this sense, the assessment the researchers can make is that challenge and competition by itself have generated this decrease. And what we find as regard to the evolution of the negative emotions, is that almost all negative emotions have been reduced, and some of them, such as rejection disappears. Anxiety decreases by up to 20%, and the only one that increases is boredom due to the repetition of the launches.

5. Discussion

This experience can be defined as "*hands-on*" activity, as described for teaching technology by Sánchez-Martín et al. [62], that is focus on "learn by doing" what means a more meaningful learning, which influence the affective domain of students.

A detailed description of the PBL methodology for Higher Education for Sustainable Development can be found on Youtube [82]. Rocket fabrication involves those skills what are encourage by Bologna Process, related to problem solving, critical thinking or cooperative learning [83] and that contributes also to Higher Education for Sustainable Development.

Wilhelm et al. [56] demand pedagogical an didactical knowledge from university educators as well as an exhaustive understanding of how to accomplish competence orientation in teaching. Breidenstein' studies reflect about the necessity of a methodological change in school lessons, traditionally lecture-style, because of being boring [84].

Rocket fabrication supposes an opportunity for students and for teachers to learn and teach by integrating ST^{2}EAM following the scientific method. Prospective teachers become "rocket scientists", experts enthusiastic and enrolled in a quite interesting task. Even though no experience like this has been described previously, NASA recommends the implementation of the rocket fabrication during school [69]. We observe that after rocket fabrication the anxiety decrease, an emotion that negatively influences on academic performance [85].

Science educators should also provide a cooperative and supportive classroom climate, for those students who remain affected by negative emotions such as anxiety or fear [86]. The emotions that prospective teachers experience towards science contents determine the emotions that they will transfer to their upcoming students [87]. Emotions greatly influence cognition, motivation, interest, and science learning, so it is necessary for teachers to be aware of the potential of emotions and how they influence the development of the classroom. This would help them to carry out their tasks by applying different methods and making decisions to foster positive emotions during the learning of science [88].

More than a few of PBL practices in higher education have been described and shared by researchers in multiple and different areas as engineering [89], medicine [90], social sciences, business management, economy [59], geography, architecture and marketing [91]. Project-Based Learning methodology has also been used with prospective teachers with the aim of teaching sciences with successful results and also including SDGs [92]. Brody and Ryu [19] implemented the PBL methodology and demonstrated the educational impacts on sustainable development. We have published an article where we obtained that prospective teachers need to improve their sustainability consciousness including behavioral changes during their training [34]. In the future, some different methodologies should be incorporated and evaluated to determine the potential effects.

Some pedagogical benefits that can be drawn from fieldwork are outlined by Anđelković et al. [27] who analyzed the opinion of 215 higher education students and concluded that fieldwork contributes to improving the didactical-methodical aspects of teaching, highlighting (1) social relations of students, (2) development of required skills, (3) increased motivation in the learning process, (4) interdisciplinary study of the problem and (5) immediate contact with objects. Other authors reports that a PBL experience at higher education provides motivation and prepares student for real practices [90]. Improved students attitudes toward learning and a deeper understanding of the subject content have been also reported [93].

Other active methodologies, such as inquiry-based learning, have been shown to improve attitudes towards science and decrease teachers in training' anxiety [94]. This methodology also makes prospective teachers realize that almost everything is somehow related to science and stimulates their own curiosity, which indicates that improving of professional and personal attitude of teachers in training are possible throughout the implementation of these affective-centered methodologies.

Jeong et al. [95] have investigated prospective teachers' emotions towards science learning when a Flipped-Classroom setting is used as instructional methodology and they also report more positive and exciting emotions (such as fun an enthusiasm) than negative and paralyzing [60] emotions. The teacher training process should address the emotional dimension in order to improve the emotions they feel by providing them with experiences that provoke changes on them by turning negative emotions into positives ones.

But it is not just about the affective domain, a research analyzing 225 studies reported that student' performance and concept inventories in STEM courses increased more when working under active learning that under traditional lecturing [96].

Controversial studies question whether training schools help teachers to learn [97] and suggest that now more than ever there is a need to improve the quality of teacher training, and this requires teachers with deep subject knowledge and this could be done by teaching for problem solving, invention and application of knowledge.

The following practical considerations can be drawn from the work:

With regard to the implications that the implementation of this methodology has on the Primary Education Degree, Church [11] recognizes how necessary school science is to enhance scientific literacy. Teachers in training will be responsible for the scientific literacy of citizen and that is why we have designed this PBL activity to meet the requirements of school science [11], set out below (a) to draw the student's attention, leading to increased their motivation, (b) offering them the PBL methodology as a resource for their professional future, (c) providing them with insights into the role of science in the current world and the impact of history, (d) empowering them and helping them to become responsible citizens. The affective domain and attitude towards science teaching are directly related to the behaviour and intention to teach science of prospective teachers [94].

The main limitation of the study is that the activity was carried out with a single group with a limited number of subjects. As it was a voluntary survey, although all students filled the first questionnaire, not all of filled the second one and therefore it was necessary to express the results as percentages.

Qualitative research is occasionally underestimated because the results are not explicitly obtained through a statistical program. However, qualitative research is necessary, even more so in education research. Jin and Bridges reveal that qualitative PBL research is growing [98]. In our case, our intention is to continue with the implementation of PBL at Higher Education in the Primary Education Degree in order to enhance our constraints, semi-structured interviews can be conducted with prospective teachers to enrich the information obtained from the questionnaires.

6. Conclusions

This work has been carried out as a part of a research on emotional and cognitive changes in teachers in training programmes through different methodologies focused in Higher Education for Sustainable Development. The strength of this research lies in eliciting the emotional performance of a PBL methodology and the exhaustive description of the experience. From the results obtained it can be concluded that, with regard to the first objective, a PBL experience has been described, offering times, materials, teaching and learning activities, and other resources. In accordance with the second objective, the emotional bias toward sciences of teachers in training showed that rocket elaboration is an enthusiastic activity and prospective teachers reported greater positive emotions than negatives ones. After the PBL implementation, an increase in positive emotions (except confidence and satisfaction in those cases where rocket failed), and a decrease in negative emotions, except boredom is reported. With these results, the authors call for an accurate scientific education for prospective teachers in order to improve the emotional dimension for future transmission by the time learners develop competencies that enable and empower them to reflect on their own actions by considering their present and future environmental, social, economic and cultural impact [99]. The scientific education of prospective teachers should be improved through methodologies that motivate and turn on their emotions that help to produce a meaningful learning [60] and to acquire scientific competencies who enable them to lead healthy, sustainable and fulfilled lives [34]. The results suggest that Project-Based Learning is a resource to enhance the positive emotions and reduce negative ones in the science lessons of prospective teachers and enable learners to contribute towards sustainable development.

Author Contributions: Conceptualization, all authors; methodology, J.S.-M.; validation, J.S.-M., I.C.-C., F.C.-C.; investigation, all authors; resources, all authors; data curation, M.H.-B.; writing—original draft preparation, M.H.-B.; writing—review and editing, all authors; visualization, J.S.-M., I.C.-C., F.C.-C; supervision, J.S.-M., I.C.-C., F.C.-C; project administration, F.C.-C.; funding acquisition, F.C.-C. All authors have read and agreed to the published version of the manuscript.

Funding: This work was funded through Research Project EDU2016-77007-R (AEI/FEDER, EU), and Govern of Extremadura (Grant GR18004).

Acknowledgments: Miriam Hernández thanks Spain's Ministry of Science, Innovation and Universities for pre-doctoral Grant (BES-2017-081566).

Conflicts of Interest: The authors declare no potential conflict of interest with respect to the research, authorship and/or publication of this article.

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Appendix. Questionnaire used in this research.

Code:
Gender:
Age:

Indicate in the following table what emotions you feel when you think about building a hydro-rocket and then explain why do you feel this way.

Emotion	Yes/No	Why?
Confidence		
Enthusiasm		
Fun		
Joy		
Satisfaction		
Surprise		
Anxiety		
Boredom		
Fear		
Nervousness		

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Rejection		
Worry		