applied sciences

MDPI

Article

Developing Project Managers' Transversal Competences Using Building Information Modeling

Francisco Zamora-Polo [1,*], Mercedes Martínez Sánchez-Cortés [2], Antonio Manuel Reyes-Rodríguez [3] and Justo García Sanz-Calcedo [3]

1 Departamento de Ingeniería del Diseño, Escuela Politécnica Superior, Universidad de Sevilla, 41011 Sevilla, Spain
2 Departamento de Ingeniería Mecánica, Energética y de los Materiales, Escuela de Ingenierías Industriales, Universidad de Extremadura, 06006 Badajoz, Spain; mercedesms@unex.es
3 Departamento de Expresión Gráfica en la Ingeniería, Escuela de Ingenierías Industriales, Universidad de Extremadura, 06006 Badajoz, Spain; amreyes@unex.es (A.M.R.-R.); jgsanz@unex.es (J.G.S.-C.)
* Correspondence: fzpolo@us.es

Received: 25 July 2019; Accepted: 18 September 2019; Published: 25 September 2019

check for updates

Featured Application: Building information modeling can be used as a virtual learning environment for developing future project managers' competences.

Abstract: The emergence of building information modeling (BIM) methodology requires the training of professionals with both specific and transversal skills. In this paper, a project-based learning experience carried out in the context of a project management course at the University of Extremadura is analyzed. To that end, a questionnaire was designed and given to students who participated in the initiative. Results suggest that BIM can be considered a virtual learning environment, from which students value the competences developed. The emotional performance observed was quite flat. Similarly, students valued the usefulness of the initiative. Students expressed a desire for the methodological change of the university classes, and thought that BIM methodology could be useful for other courses. The results obtained show a line of work to be done to improve the training of students and university teaching.

Keywords: BIM; project engineering; project management; higher education; technology education; competences; emotions; soft skills; collaborative models

1. Introduction

The irruption of information and communication technologies (ICTs) is changing our lives. In the Architecture Engineering Construction and Operations (AECO) industry, a methodology based on the use of ICTs, called building information modeling (BIM), aims to improve the efficiency of the sector, reduce the fragmentation of the industry, and ensure proper coordination between all agents involved in a building project [1]. BIM could be defined as: "a set of interacting policies, processes and technologies generating a methodology to manage the essential building design and project data in digital format throughout the building's life-cycle" [1,2]. BIM applications are very diverse. They can include coordination of construction stakeholders [3,4], control of the costs of projects [5], scheduling [6], promotion of sustainability of the project [7–9], caring for the associated heritage [10], or safety and health at work [11,12], among others. In any case, education is crucial for the successful implementation of the BIM methodology in the AECO industry [13,14].

In this context, our world requires citizens and professionals prepared to face the new challenges of humanity (e.g., climate change, growing inequality, etc.) [15,16]. In order to achieve this goal, it is necessary that all the educational stages are oriented towards the development of the students' competences [13,15–18]. The term competence could be defined as the integration of knowledge, skills, and attitudes to respond to a specific situation [13,18,19]. The job market requires professionals with new characteristics. According to a report from the World Economic Forum [20], 65% of primary school children in 2016 will work in positions that do not currently exist. University students must develop specific and transversal competences [13,15–17,20–22]. Specific competences are directly related to the development of a profession [13,15,17,22]; in the case of project management: risk management, budget management, project resource management, scheduling, etc. Transversal competences are shared by different professions and can be used in the development of a critical and committed citizenship [13,15–17,22]; for example: teamwork, learning to learn, communication in one's own language and foreign languages, etc. The professional of the 21st century must be a humanist, who is willing to learn throughout their life and who is capable of working with others to achieve a certain objective.

Most of the articles published about BIM include technical aspects. Although there is a growing body of knowledge around the teaching of BIM, the articles that address this topic are scarce. In a previous paper, a conceptual framework for the use of BIM was proposed [13]. In this paper, we try to cover three gaps presented in the literature. Firstly, in a previous paper we theorized that BIM can be used as a virtual learning environment [13]; nevertheless, as far as we know, students' opinions have not been explored. In this work, students were asked about whether BIM meets the characteristics of a virtual learning environment. There is a consensus about the need for competence-development by students; however, more studies are needed to know which methodology is the best for competence-development. In this paper, the development of soft skills using problem-based learning is analyzed. Finally, emotions play a crucial role in students' motivations; it is important to increase knowledge about the emotions felt by students when using BIM.

The objectives of this research are:

- To describe a project-based learning experience in the field of a university course about project management through the use of BIM;
- To analyze the main transversal competences developed by the students and the emotions felt by students;
- To analyze whether BIM can be considered a virtual learning environment;
- To determine whether there are differences in the previous aspects depending on the degrees studied.

The structure of the article is as follows: in Section 2, a review of the literature is presented; subsequently, methodology is described in Section 3. In Section 4, the results are presented. The results are then discussed and some practical implications are exposed (Section 5). Finally, in Section 6, conclusions and future works are presented.

2. Literature Review

The adoption of BIM methodology has been slower than expected [23]. In order to overcome this difficulty, education plays a crucial role [14,24,25]. There is a high demand for BIM training from companies in the construction sector [26–29].

Sacks and Pikas developed a framework to understand the relationship between BIM and education [30]. Firstly, they analyzed the needs of the labor market through LinkedIn discussion forums, the development of international workshops, and the analysis of job offers. Subsequently, they developed several tables gathering the training demands that were analyzed by several experts. Finally, they analyzed several experiences in different countries [30].

From a pedagogical point of view, it is necessary to start from the demands for skills on the part of the labor market and society in order to effectively design teaching-learning activities [31–33]. The development of specific and transversal competences is important for the training of professionals and citizens [13,16,17,22,34]. The former are intimately related to the development of the profession, while the latter are related to the exercise of the profession, and to the exercise of critical and committed citizenship [13,16,17,22]. In addition, there is a growing demand for training in both specific and transversal competences by accreditation agencies; e.g., the US Accreditation Board for Engineering and Technology (ABET) and the European Network for the Accreditation of Engineering Education (ENAEE) [32]. As previously indicated, transversal competences are highly valued by companies [20,21], and are deeply important in the construction of a fairer society [15,16,21,35]. The evaluation of these competences is crucial [21] and is not easy, so it is necessary to study them more closely.

Skills required for project management have been previously addressed both from the point of view of research [36], and by entities dedicated to the certification of project managers, such as the Project Management Institute (PMI) [37] and the International Project Management Association(IPMA) [38]. There is a consensus on the importance of transversal competences for the role of project manager [36–38]. There are several methodologies that can be used in the teaching of BIM, among them the active participation of the student within a constructivist approach to the process of teaching/learning [13]. In this sense, there are several initiatives that use novel methodologies, such as project-based learning [39–43], flipped classroom [40], or gamification [41,44,45].

Numerous initiatives published in the literature have opted for the use of project-based learning (PBL) [46]. In this methodology, the students learn by doing a project, generally carried out in group [43,47]. The characteristics of this methodology have been described as: a constructivist methodology, in which students build knowledge, and it is similar to the professional future of the students. It requires collaboration between teachers and students, and between students themselves.

There are several strategies for the design of training activities in BIM, ranging from the creating a course specifically to address this issue, coordinated work in various subjects, or the development of capstone projects [13,26,28,48].

Students' lack of motivation is one of the challenges of science, technology, engineering, and mathematics (STEM) education [49]. Innovative activities can improve this motivation [50,51]. In this sense, numerous studies have shown the relationship between emotions and the development of the teaching-learning process [52–58]. Recently Zou et al. have studied the opinions of students regarding the use of the BIM methodology [59]. Zhang et al. described a project-based learning initiative, and in that paper they propose a framework that includes the implementation of activity planning, development, and evaluation [43]. In a recent study, Suwal and Singh studied the sentiments experienced by students in a construction project management course [57]. They found that students' feelings were predominantly positive [57].

The inclusion of BIM in the educational field has a series of entry barriers [60,61]:

- Sometimes it is a requirement to acquire licenses for the software used or to sign agreements with the companies for its use in the student version.
- It is a slow process with a clear social dimension. The competences that are developed are fundamentally transversal, and specific competences are usually given priority in technical studies.
- These methodologies require that the center be placed in the students.
- It requires a collaboration between various degrees and courses various subjects.
- Professors need training, and these initiatives require a long time for preparation and tutoring.

All these factors justify the need to investigate the application of BIM in university teaching with the aim of contributing to the improvement of student training.

3. Methodology

3.1. Data Collection

A questionnaire was developed for data collection. This questionnaire is presented in Appendix A. The questionnaire had 8 blocks. The first one was dedicated to sociological variables, such as gender, age, degree, and previous studies (Q1–Q4). Subsequently, in a second block, students were asked about their previous experience with the BIM methodology (Q5–Q6). Then, the students were asked about the use of BIM as a virtual learning environment (VLE); for this purpose, the dimensions of a VLE were those proposed by Dillenbourg et al. [62] (Q7–Q13). Afterwards, students were asked about the competences developed during the use of BIM; the development of that section of the questionnaire was based on that proposed by Prieto-Muriel [63] (Q14–Q30). The emotional performance of the experience was evaluated using Q31–Q40, considering five positive emotions and five negative emotions.

There are several strategies in order to evaluate students' emotions. Suwal and Singh [57] used SA to classify students' attitudes by classifying attributes into positive, negative, or neutral. Other authors have chosen to use an score from 0 to 10 to analyze emotions [58,64,65]. In our case we use a scale from 1 to 5 in order to evaluate students' feelings; these questions have previously been used to analyze a gamification experience [66].

The utility perceived by the students was measured by Q42–Q46 questions. Students were asked about the need for methodological change at the university (Q47–Q49). Finally, students were asked about the number of hours (Q50) and resources used during the experience (Q51).

The design process of the questionnaire was as follows: first, a bibliographic search was carried out among studies of a similar nature in order to design our questionnaire [15,63,67]; then, the draft questionnaire was studied by experts external to the research. The questionnaire was reviewed by an expert in the didactics of science and technology and by an expert in virtual education. As a result of their advice, some changes were made to the structure and writing of the questionnaire [68]. The experts proposed modifications to the writing of the questions and that the number of questions related to positive emotions should be equal to the number of questions associated with negative emotions.

The questionnaire was provided in paper format. There are numerous works in which the questionnaire was provide in digital format (e.g., Google Form) [69,70]. This format has some advantages; for example, its transcription is quasi automatic. However, in some cases, the number of responses obtained was not very high, [15,50,67]. This was the primary reason why the paper version was chosen. Students were informed of the purpose of the research, and informed consent was obtained.

3.2. Activity Description

The analized experience was developed in a course called "Projects." This course is scheduled in the first semester of the fourth year of the following degrees: electronic and automatic engineering, mechanical engineering, materials engineering, and electrical engineering. These degrees are taught at the School of Industrial Engineering of the University of Extremadura (Spain). The course requires 150 h of students' personal work (6 European Credit Transfer System). The syllabus of the course can be consulted elsewhere [71]. Topics such as project management, laws and regulations applicable to industrial projects, and computer applications used in the development and management of projects, are addressed in this course.

In order to apply theoretical knowledge, a project-based learning activity was programmed. In this activity, a technical project developed using BIM methodology was designed by students. This project included: an environmental impact study, a health and safety study, etc. The objectives of this project were: (1) Understand the advantages and disadvantages of BIM tools and methodologies for the development of building projects. (2) Create a model of a medium complexity project and its complete technical documentation. (3) Integrate the coordination of the information of a building project into a single digital model, developing clash detection, schedule programming, and cost simulation. This activity was developed in groups of four students (two students of mechanical engineering, one student of electronic and automatic engineering, and one student of electrical or materials engineering). Students played different roles in the group [27].

In 2018/2019, all groups focused on a supermarket. In each academic year, the subject matter of the projects analyzed changes; for example, in previous years, the developments were: gas stations, car dealers, warehouses, etc. For the development, the students used the software Naviswork(Autodesk, San Rafael, California, USA) [72] and Revit [73] (Autodesk, San Rafael, California, USA). The university has signed an agreement that allows the use of these programs in their student version to all members of the university community (teachers, staff, and students).

Students developed the project and realized 4 deliveries throughout the course. They uploaded, using a virtual platform (Moodle): (1) the virtual model, (2) the preliminary design, and (3) the execution project. At the end of the semester, the students delivered all the documentation of the project and made a public exhibition that was evaluated by a panel of three professors of the course.

3.3. Sample

The sample used consisted of 66 students from: mechanical engineering (29), electrical engineering (4), materials engineering, (2) and electronic and automatic engineering (22). The average age was 22.6 years old, with a minimum of 21 and a maximum of 27 years old. The percentage of male students in the sample reached 74.24%.

3.4. Data Processing

In order to analyze obtained data, the Statistical Package for Social Science (SPSS)(IBM) software version 23 for Windows (IBM, Chicago, USA) was used [74]. A descriptive analysis of results was developed using this computer software. Similarly, although with unsuccessful results, hypothesis contrasts were made to compare of the results between two groups (mechanical engineering students and the rest of the students). First of all, a Shapiro–Wilk test was carried out on the results obtained in order to confirm normality of the sample. Since samples were not normal, the hypothesis contrast used was the Mann–Withney test. This division into two groups of students is justified by the content taught in the grades. Usually mechanical engineering graduates identify more with the construction sector, as opposed to the rest of the students with the degrees in electrical, electronic, and materials engineering.

4. Results

The questionnaire was applied in the last two weeks of the classes of the course. Most of the students had one semester's exposure to BIM. Although students had some exposure to this methodology (Q5, mean = 2.62; STD = 1.557), the previous knowledge they had was not very high (Q6, mean = 1.47; std = 0.649).

Table 1 shows the results of the questions related to the use of BIM as a VLE. As can be seen, most items scored more than three (4 over 7). However, the values are not very high. Three items with a higher value correspond to the statements related to the diversity of ways of displaying information, BIM allowing the integration of different programs, and BIM enriching the face-to-face classes of the subject. In order to check whether there were differences between the students taking the mechanical engineering degree and the rest of the degrees, the Mann–Withney test was carried out for independent samples. Results show that for all items, there were no significant differences between the medians in the two groups.

Secondly, Table 2 shows the results of students' opinions regarding competences developed in the activity.

As shown in Table 2, students believed that the most developed competence in the activity was autonomous learning, followed by creativity and adaptation to new situations. In addition, the least developed competences were: oral and written communication, ethical competences, and organizational and planning skills. Once again, no significant differences were found between the results obtained from the mechanical engineering graduates and those who do not take that degree.

In order to analyze the emotional performance of the activity developed, Table 3 shows the emotions experienced by students. As can be inferred from the results, values on most occasions are close to 3 (neutral value). This seems to indicate that the emotional impact on students is not very high.

Table 1. Key features of building information modeling (BIM) as a virtual learning environment (VLE).

Item	Mean	STD	Ranking	Sig. Differences (Mechanical/ No Mechanical)	*p*-Value
BIM is a space where information is shared.	3.38	1.034	4	No	0.566
BIM is a social space.	2.80	1.143	7	No	1.000
In BIM, information can be represented in different ways	4.00	.911	1	No	0.910
BIM allows integrating the knowledge of the subject.	2.88	1.089	6	No	1.000
BIM is a complement to enrich the face-to-face classes.	3.42	1.138	3	No	1.000
BIM methodology integrates different programs for modeling, calculation of structures, installations, etc.	3.82	.959	2	No	0.910
BIM methodology requires keep in contact with other members of the group	2.92	1.241	5	No	0.143

Table 2. Competences developed during project based learning using BIM.

Competence	Mean	Std	Ranking	Sig. Differences (Mechanical/ No Mechanical)	*p*-Value
Ability to analyze and synthesize	2.60	1.087	14	No	0.200
Organizational and planning skills	2.55	0.995	15	No	0.946
Oral and written communication	1.85	.0.925	17	No	0.782
Computer skills related to the field of study	3.00	1.081	9	No	0.449
Information management skills	2.92	0.966	10	No	0.802
Ability to solve problems	3.17	1.032	7	No	0.247
Decision-making	3.29	1.120	6	No	0.936
Work in group	3.52	1.062	4	No	0.565
Work in group in multidisciplinary context	3.32	1,062	5	No	0.204
Interpersonal relationship skills	2.67	1.207	13	No	0.354
Critical thinking	2.71	1.134	11	No	0.830
Ethical commitment	2.44	1.153	16	No	0.477
Self-directed learning	4.18	0.991	1	No	0.428
Adaptation to new situations	3.66	1.079	3	No	0.681
Creativity	3.76	1.253	2	No	0.232
Leadership	2.67	1.244	12	No	0.636
Quality motivation	3.06	1.444	8	No	0.150

Table 3. Emotions experienced by students during the activity.

Typology	Emotion	Mean	STD	Sig. Differences (Mechanical/No Mechanical)	*p*-Value
Negative	Despondency	3.36	1.495	No	0.525
	Worry	3.26	1.269	No	0.268
	Nervousness	2.91	1.444	No	0.628
	Tedium	2.26	1.244	No	0.275
	Fear	2.05	1.352	No	0.329
Positive	Enthusiasm	3.30	1.109	No	0.514
	Surprise	2.79	1.283	No	0.968
	Happiness	2.45	1.238	No	0.093
	Confidence	2.44	0.844	No	0.810
	Calm	2.23	1.020	No	0.152

Table 4 shows the results of the usefulness of the experience from the students' point of view.

Table 4. The usefulness of the project-based learning experience using BIM.

Usefulness	Mean	STD	Sig. Differences (Mechanical/ No Mechanical)	*p*-Value
This experience helps to find work in the national market	3.44	1.025	No	0.603
This experience helps to find work in the international market	3.44	1.054	No	0.187
Project complexity	3.65	0.832	No	0.592
Project coordination	3.71	0.957	No	0.995
BIM contributes to improving the professional framework of engineering	3.68	0.963	No	0.951

As can be inferred from Table 4, students fundamentally value the knowledge provided about the coordination of the project, as well as the fact that BIM contributes to having a complete vision of the project. Moreover, students believe that BIM contributes to improving the professional framework of engineering.

Regarding students' opinions, a methodological change should take place at the university. Table 5 shows the results of questions Q47–Q49. Students demand a methodological change that includes technology in university classrooms and think that BIM should be included in their university education and in other courses in addition to project management.

Table 5. The need for a methodological change at the university.

Question	Mean	STD	Sig. Differences (Mechanical/No Mechanical)	*p*-Value
University requires a technological evolution.	4.50	0.836	No	0.173
Incorporating BIM into university education is necessary in Engineering and Architectural studies.	4.39	0.959	No	0.720
Knowledge of BIM can be useful for other subjects.	3.86	1.162	No	0.584

These results should be understood in conjunction with the students' responses to question 51. Students were asked about the resources they had used to train themselves outside of the classes given at the university. Figure 1 shows results in percentages of students using each of the resources. The use of internet tutorials, used by almost all the students who completed the survey, is clearly noteworthy.

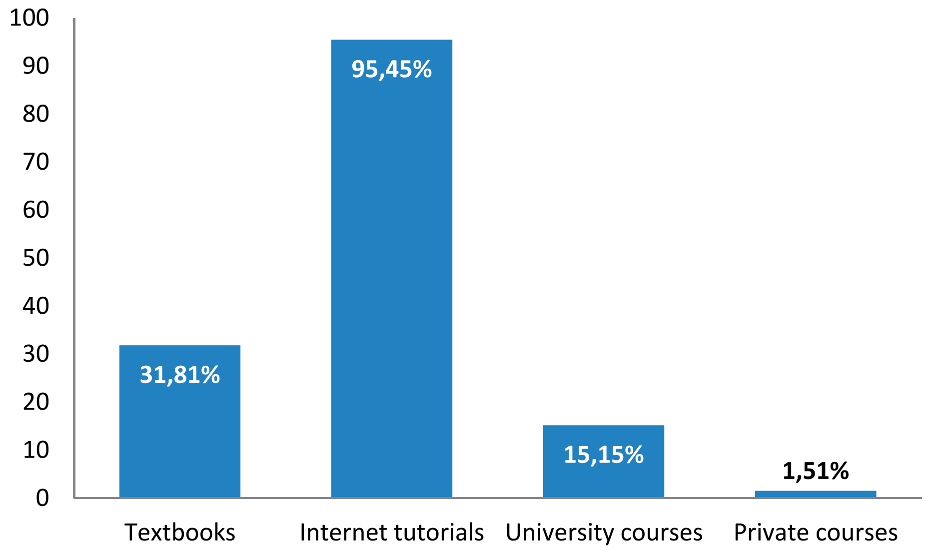

Figure 1. Resources used by students, expressed as percentages.

Finally, students were asked about the number of hours they had devoted to the development of the activity. The average value of their response was 56.58 h (std: 42.69). This result was higher than initially anticipated by professors.

5. Discussion

No significant differences were found between mechanical engineering students and the rest of the degrees involved in the study in results shown in previous section. Initially, it could be expected that students more directly related to the construction sector (mechanical engineering) would provide different answers in some items of the questionnaire. Numerous studies show BIM application among students of architecture [40,75,76], civil engineering [27,43,50,76], mechanical engineering [76], and so on.

The above results show the multidisciplinary character of BIM. This tool can be useful for different stakeholders in the construction sector.

Regarding the use of BIM as a virtual learning environment, students value that BIM represents the information in multiple ways, integrating diverse programs; for example, the calculations pertaining to structures and facilities could be considered the DNA of BIM methodology; however, students believe that the use of BIM enriches the face-to-face classes. Surprisingly, students do not value the social character of BIM; the low valuation of the items associated with this question could be related to the physical proximity the students had to one another at the time of doing the work.

Results seem to indicate that BIM can be used as a virtual learning environment. However, professors must create conditions for this environment to be exploited to the maximum and all its potentialities to be developed.

Students value the development of transversal competences (Table 2). The development of students' skills is the ultimate goal of university teaching [13,77]. Students should receive training throughout their academic lives that enables them to develop their profession efficiently and to exercise critical citizenship. In this context, transversal competences are crucial for better adaptation to an environment that is doomed to profound and permanent changes. In fact, these skills are highly valued in project management [36–38].

Many studies in the scientific field deal with the development of competences with BIM [29,30,32,78], including technical and transversal competences. Among the latter, Sacks and Pikas [30] pointed out open mindedness, self-learning capabilities, communication, team-work, leadership, etc. In this initiative, the more developed competences, according to students' opinions, are autonomous learning, adaptation to new situations, and creativity. Nowadays, these competences are very important. In fact, Harari [79], in his best seller "21 lessons for the 21st century," mentions that at the present time, it is necessary to teach in 4 Cs: critical thinking, creativity, communication, and collaboration, collecting those previously proposed by specialists in pedagogy [80,81]. Our study is in line with previously published studies that mentioned project-based learning activities contributing to such capabilities as problem-solving skills, critical thinking, holistic project vision [82], and transversal competences [60]. Students also value learning to work in teams, especially multidisciplinary ones.

The above results seem to indicate that BIM can be a tool for the development of transversal competences by students. This result is very interesting because the construction sector requires this kind of skills [46,83].

Regarding emotions, Bujacz et al. [84] indicate that the development of novel activities could be associated with positive emotions in students. Muntaner-Mas et al. [53] related positive emotions to learning methodologies; and they did not find a relationship between negative emotions and learning methodologies. In any case, they showed there are a multitude of studies that relate emotions to the development of the teaching-learning process [54–56]. Emotional control is one of the competencies identified by Nijhuis et al. [36] in their taxonomy of competences needed for project management. In fact, in the future, students will probably have to manage negative emotions such as anxiety, fear, or frustration in their work. In the experience analyzed, the highest scoring emotions were despondency, worry, and enthusiasm. In any case, the score was not very high compared to previously conducted studies [66]. Within the scope of the BIM methodology, Suwal and Singh [57] analyzed the students' feelings towards a BIM learning platform. Their results showed that the students' feelings were mainly positive. Lassen et al. [50] showed that the use of BIM in university teaching leads to an increase in student motivation.

Our results show quite flat emotional performance. Previous work has shown an improvement in emotional performance (positive emotions superior to negative) associated with use of BIM [57], gamification [54,66], or flipped classroom [56,65,85] in disciplines of science, engineering, architecture and mathematics (STEM). Our results seem to indicate that the use of an active methodology, in our case PBL, does not necessarily mean an increase in emotional performance. It is be necessary to investigate if the incorporation of elements of gamification or flipped classroom can improve this emotional performance.

With regard to usefulness, a constant in technical studies is the lack of motivation of the students [49]. As previously shown, BIM can contribute to increasing student motivation [50]. Previously studies have shown that BIM has potential benefits for project managers [57]. Sacks and Pikas [30] pointed out that BIM can help students become aware of the complexity of projects. Zou et al. [59] studied the opinion of students regarding the usefulness of BIM. In their work, students appreciate that BIM contributes to architectural design, structural design, building services design, and management of the construction process. Zhang et al. [43] pointed out that BIM activities, according to student's opinions, helped them to study and work. In previous studies, students pointed out that the use of BIM at the university was very interesting [29], because it would allow them to obtain skills valued in the labor market and a greater connection with industry [50]. The utility values provided by students in previous studies are superior to those obtained in this study.

The results shown in Figure 1 show a generational change in the students. As Macdonald and Granroth [83] previously pointed out, the "Google Generation" has arrived in university classrooms. Students are currently looking for information on the Internet (e.g., through video tutorials) rather than using a textbook. This is certainly a challenge for universities. Students sometimes prefer Massive Open Online Courses and low-cost courses over traditional classes [83].

In our opinion, a possible alternative in order to improve the results of this initiative could be to use the flipped classroom methodology. Recent studies have shown a positive effect of this methodology on university teaching [56,65,85,86]. It favors the active participation of students, contributes to the self-regulation of the teaching-learning process, and improves emotional performance. In a similar way to the proposal of Boeykens et al. [40], students have available a series of video tutorials to help them in the process of elaboration of the project. The inclusion of these videos can be enriched with forums that can be developed online [40]. These initiatives have been explored by other authors [87]. Table 5 suggests it is necessary to realize methodological changes in the university classes, as demanded by students (Table 5).

Finally, it is crucial to control the total duration of the activities designed in the course [40,43,88]. In the experience analyzed, students claim to have spent 56.58 h on the project (std: 42.69); this duration is one third of the total load of the course (150 h). The workload is greater than initially foreseen in the syllabus. Students communicated to the teachers that they were overburdened. This aspect may be inferring in the development of the activity. This working load should be controlled and reviewed in future editions; it is likely that the creation of tutorials or learning guides can reduce it.

Practical Implications and Limitations

In our opinion, the following practical considerations can be drawn from the work:

1. Methodology: one of the fundamental aspects for the success of this type of initiative is the choice of the correct methodology [25]. Students should feel motivated in the development of the task, and on the other hand, the workload should be conveniently estimated [43,87,88]. In these types

of activities, resources to help the development of the task (i.e., videos) should be provided to students, as well as proper documentation and help to guide teamwork and the activity [43].

2. Professor work-load: Another aspect that must be controlled is the degree of dedication of the teaching staff. In some previous works, it has been pointed out that these types of activities generate an enormous amount of work for the teachers of the subject [89,90]. To that end, it would be interesting to introduce tools that allow the activity to be carried out without excessively increasing the professors' workload.
3. Learning throughout the curriculum: this activity was developed for the last course of the degree; it would be interesting to introduce BIM methodology earlier. In this sense, some previously published works have indicated the possibility of collaboration between different subjects. For example, Wu and Hyatt develop the same project with the collaboration of students from four different courses [41].

The main limitation of the study is the limited number of subjects that have participated in the initiative and that it is not possible to know the temporal evolution of the initiative. These aspects will be addressed in future works.

6. Conclusions and Future Works

The emergence of the BIM methodology requires the training of future professionals. The university can play a crucial role in this task.

In this work, the experience of teaching BIM through the use of the project-based learning methodology has been analyzed. From the results obtained, it can be concluded that, according to the opinion of students, BIM can be considered a virtual teaching-learning environment; the teachings of BIM can contribute to the development of transversal competences; those competences are very important in the development of professional and civic life. In particular, those competences are crucial for the project management profession. The students' emotional performance was quite flat; a prevalence of positive or negative emotions could not be distinguished. Students consider the development of experience to be useful and demand a methodological change in university teaching. A change in the information-seeking strategy can be inferred from students' responses. Results shown here contribute to improving the knowledge that the scientific community has about teaching BIM. In most previously published works, positive emotions outweighed negative emotions. That way, the innovative activity led to an increase in student motivation. The results obtained are different, and invite one to take the educational innovations with greater prudence.

This work is part of a broader research line on the development of transversal competences in higher education. Previous studies have shown that the incorporation of methodologies such as flipped classroom and gamification increase the emotional performance of students [54,56,65,66]. Thus, in the future, we plan to incorporate those methodologies into the initiative and evaluate its implementation to determine whether they also have positive effects in BIM education. One aspect that is attracting deep interest from the scientific community is the promotion of sustainability in higher education [15–17,35,41,67]. In future work, the contribution of education in BIM to the promotion of sustainability can be studied. Although the information from the questionnaires is very interesting, semi-structured interviews may be conducted in the future to enrich the information obtained from the sample [91].

Author Contributions: Conceptualization, F.Z.-P.; methodology, F.Z.-P. and M.M.S.-C.; formal analysis: F.Z.-P.; investigation, F.Z.-P. and M.M.S.-C.; resources, J.G.S.-C.; writing—original draft preparation, F.Z.-P.; writing—review and editing, F.Z.-P. and M.M.S.-C.; visualization, F.Z.-P.; supervision, F.Z.-P and J.G.S.-C.; funding acquisition: J.G.S.-C. and A.M.R.-R.

Funding: This work was funded by European Social Fund through Research Projects GR-18029 and GR-18086 linked to the VI Regional Plan for Research, Technical Development and Innovation from the Regional Government of Extremadura (2017–2020).

Acknowledgments: The authors thank M. Guerrero-González for her comments and suggestions on the preliminary versions of the manuscript.

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

Appendix A

Table A1. Sociological questions.

Question Number	Question Text	Variable Type	Options
Q1	Gender	Categorical	Male Female
Q2	Age	Quantitative	
Q3	Previous studies	Categorical	High school Vocational training
Q4	Degree	Categorical	Mechanical Engineering Electrical Engineering Electronic and automatic engineering Materials Engineering

Table A2. Previous knowledge of BIM.

Question Number	Question Text	Variable Type	Options
Q5	I had used a 3D modeling program prior to the start of the course	Ordinal	Likert scale (1–5) [1]
Q6	I had used BIM before the beginning of the assignment.	Ordinal	Likert scale (1–5) [1]

[1] Indicate the degree of agreement or disagreement with the following statements: (1) Strongly disagree; (2) disagree; (3) neither agree nor disagree; (4) agree; (5) strongly agree.

Table A3. Characteristics of BIM as a virtual learning environment.

Question Number	Question Text	Variable Type	Options
Q7	BIM is a space where information is shared.	Ordinal	Likert scale (1–5) [1]
Q8	BIM is a social space. It is possible to interact with other people by various ways.	Ordinal	Likert scale (1–5) [1]
Q9	In BIM methodology, information can be represented in different ways such as text, three-dimensional objects, planes, etc.	Ordinal	Likert scale (1–5) [1]
Q10	BIM allows integrating the knowledge of the subject.	Ordinal	Likert scale (1–5) [1]
Q11	BIM is a complement to enrich the face-to-face classes.	Ordinal	Likert scale (1–5) [1]
Q12	BIM methodology integrates different programs for modelling, calculation of structures, installations, etc.	Ordinal	Likert scale (1–5) [1]
Q13	BIM methodology requires keep in contact with other members of the group.	Ordinal	Likert scale (1–5) [1]

[1] Indicate the degree of agreement or disagreement with the following statements: (1) strongly disagree; (2) disagree; (3) neither agree nor disagree; (4) agree; (5) strongly agree.

Table A4. Transversal competences developed with BIM.

Question Number	Question Text	Variable Type	Options
Q14	I have developed the competence: "ability to analyze and synthesize" using BIM.	Ordinal	Likert scale (1–5) [1]
Q15	I have developed the competence: “organizational and planning skills” using BIM.	Ordinal	Likert scale (1–5) [1]
Q16	I have developed the competence: “oral and written communication” using BIM.	Ordinal	Likert scale (1–5) [1]
Q17	I have developed the competence: “Computer skills related to the field of study” using BIM.	Ordinal	Likert scale (1–5) [1]
Q18	I have developed the competence: “Information management skills” using BIM.	Ordinal	Likert scale (1–5) [1]
Q19	I have developed the competence: “Ability to solve problems” using BIM.	Ordinal	Likert scale (1–5) [1]
Q20	I have developed the competence: “Decision–making” using BIM.	Ordinal	Likert scale (1–5) [1]

Table A4. *Cont.*

Question Number	Question Text	Variable Type	Options
Q21	I have developed the competence: "Work in group" using BIM.	Ordinal	Likert scale (1–5) [1]
Q22	I have developed the competence: "Work in group in multidisciplinary context" using BIM.	Ordinal	Likert scale (1–5) [1]
Q23	I have developed the competence: "Interpersonal relationship skills" using BIM.	Ordinal	Likert scale (1–5) [1]
Q24	I have developed the competence: "Critical thinking" using BIM.	Ordinal	Likert scale (1–5) [1]
Q25	I have developed the competence: "Ethical commitment" using BIM.	Ordinal	Likert scale (1–5) [1]
Q26	I have developed the competence: "Self-directed learning" using BIM.	Ordinal	Likert scale (1–5) [1]
Q27	I have developed the competence: "adaptation to new situations" using BIM.	Ordinal	Likert scale (1–5) [1]
Q28	I have developed the competence: "creativity" using BIM.	Ordinal	Likert scale (1–5) [1]
Q29	I have developed the competence: "leadership" using BIM.	Ordinal	Likert scale (1–5) [1]
Q30	I have developed the competence: "quality motivation" using BIM.	Ordinal	Likert scale (1–5) [1]

[1] Indicate the degree of agreement or disagreement with the following statements: (1) Strongly disagree; (2) disagree; (3) neither agree nor disagree; (4) agree; (5) strongly agree.

Table A5. Emotional performance.

Question Number	Question Text	Variable Type	Options
Q31	I have experienced nervousness during the use of BIM.	Ordinal	Likert scale (1–5) [1]
Q32	I have experienced worry during the use of BIM.	Ordinal	Likert scale (1–5) [1]
Q33	I have experienced tedium during the use of BIM.	Ordinal	Likert scale (1–5) [1]
Q34	I have experienced fear the use of BIM.	Ordinal	Likert scale (1–5) [1]
Q35	I have experienced despondency during the use of BIM.	Ordinal	Likert scale (1–5) [1]
Q36	I have experienced enthusiasm during the use of BIM.	Ordinal	Likert scale (1–5) [1]
Q37	I have experienced calm during the use of BIM.	Ordinal	Likert scale (1–5) [1]
Q38	I have experienced confidence during the use of BIM.	Ordinal	Likert scale (1–5) [1]
Q39	I have experienced happiness during the use of BIM.	Ordinal	Likert scale (1–5) [1]
Q40	I have experienced surprise during the use of BIM.	Ordinal	Likert scale (1–5) [1]

[1] Indicate the degree of agreement or disagreement with the following statements: (1) Strongly disagree; (2) disagree; (3) neither agree nor disagree; (4) agree; (5) strongly agree.

Table A6. Perceived utility of BIM use.

Question Number	Question Text	Variable Type	Options
Q42	The use of BIM will provide me with greater opportunities to find work at the national market.	Ordinal	Likert scale (1–5) [1]
Q43	The use of BIM will provide me with greater opportunities to find work at the international market.	Ordinal	Likert scale (1–5) [1]
Q44	The use of BIM has given me a complete overview of the project.	Ordinal	Likert scale (1–5) [1]
Q45	With BIM a better coordination of the projects can be carried out.	Ordinal	Likert scale (1–5) [1]
Q46	BIM contributes to improve the professional framework of engineering.	Ordinal	Likert scale (1–5) [1]

[1] Indicate the degree of agreement or disagreement with the following statements: (1) Strongly disagree; (2) disagree; (3) neither agree nor disagree; (4) agree; (5) strongly agree.

Table A7. Need for change in the university context.

Question Number	Question Text	Variable Type	Options
Q47	University requires a technological evolution.	Ordinal	Likert scale (1–5) [1]
Q48	Incorporating BIM into university education is necessary in Engineering and Architectural studies.	Ordinal	Likert scale (1–5) [1]
Q49	Knowledge of BIM can be useful for other subjects.	Ordinal	Likert scale (1–5) [1]

[1] Indicate the degree of agreement or disagreement with the following statements: (1) Strongly disagree; (2) disagree; (3) neither agree nor disagree; (4) agree; (5) strongly agree.

Table A8. Dedicated hours and resources used.

Question Number	Question Text	Variable Type	Options
Q50	How many hours have you dedicated to the project? (0–150)	Quantitative	
Q51	What resources have you used to support the learning of the BIM software?	Categorical	Textbooks Internet tutorials University courses Private entity courses

References

1. Succar, B. Building information modelling framework: A research and delivery foundation for industry stakeholders. *Autom. Constr.* **2009**, *18*, 357–375. [CrossRef]
2. Penttilä, H. Describing the changes in architectural information technology to understand design complexity and free-form architectural expression. *Electron. J. Inf. Technol. Constr.* **2006**, *11*, 395–408.
3. Petri, I.; Beach, T.; Rana, O.F.; Rezgui, Y. Coordinating multi-site construction projects using federated clouds. *Autom. Constr.* **2017**, *83*, 273–284. [CrossRef]
4. Bryde, D.; Broquetas, M.; Volm, J.M. The project benefits of Building Information Modelling (BIM). *Int. J. Proj. Manag.* **2013**, *31*, 971–980. [CrossRef]
5. Santos, R.; Costa, A.A.; Silvestre, J.D.; Pyl, L. Integration of LCA and LCC analysis within a BIM-based environment. *Autom. Constr.* **2019**, *103*, 127–149. [CrossRef]
6. Candelario-Garrido, A.; García-Sanz-Calcedo, J.; Reyes Rodríguez, A.M. A quantitative analysis on the feasibility of 4D Planning Graphic Systems versus Conventional Systems in building projects. *Sustain. Cities Soc.* **2017**, *35*, 378–384. [CrossRef]
7. Chong, H.-Y.; Lee, C.-Y.; Wang, X. A mixed review of the adoption of Building Information Modelling (BIM) for sustainability. *J. Clean. Prod.* **2017**, *142*, 4114–4126. [CrossRef]
8. Cavalliere, C.; Dell'Osso, G.R.; Pierucci, A.; Iannone, F. Life cycle assessment data structure for building information modelling. *J. Clean. Prod.* **2018**, *199*, 193–204. [CrossRef]
9. Reizgevičius, M.; Ustinovičius, L.; Cibulskienė, D.; Kutut, V.; Nazarko, L. Promoting Sustainability through Investment in Building Information Modeling (BIM) Technologies: A Design Company Perspective. *Sustainability* **2018**, *10*, 600. [CrossRef]
10. Martínez, M.L.; Carretero, A.; Sanz, J.D.; Álvarez, P. Modelo de valoración patrimonial de un elemento singular: La cúpula de la escuela técnica superior de ingenieros industriales. *Inf. Construcción* **2018**, *70*, 254. [CrossRef]
11. Tixier, A.J.-P.; Hallowell, M.R.; Rajagopalan, B.; Bowman, D. Construction Safety Clash Detection: Identifying Safety Incompatibilities among Fundamental Attributes using Data Mining. *Autom. Constr.* **2017**, *74*, 39–54. [CrossRef]
12. Choe, S.; Leite, F. Construction safety planning: Site-specific temporal and spatial information integration. *Autom. Constr.* **2017**, *84*, 335–344. [CrossRef]
13. Zamora-Polo, F.; Luque-Sendra, A.; Sánchez-Martín, J.; Aguayo-González, F. Conceptual Framework for the Use of Building Information Modeling in Engineering Education. *Int. J. Eng. Educ.* **2019**, *35*, 744–755.

14. Eleftheriadis, S.; Mumovic, D.; Greening, P. Life cycle energy efficiency in building structures: A review of current developments and future outlooks based on BIM capabilities. *Renew. Sustain. Energy Rev.* **2017**, *67*, 811–825. [CrossRef]
15. 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. [CrossRef]
16. 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. [CrossRef]
17. Zamora-Polo, F.; Román-Suero, S.; Sánchez-Martín, J. From Efficiency to sustainability. Training responsible engineers in the new educational scene. *Dyna Ing. Ind.* **2010**, *85*, 575–580. [CrossRef]
18. 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.
19. Mateos, V.L.; Montanero, M.; Gómez, V.; Salamanca, S. *Diseño e Implantación de Títulos de Grados en el Espacio Europeo de Educación Superior*; Ediciones Narcea: Madrid, Spain, 2008; ISBN 9788427716292.
20. World Economic Forum. *The Future of Jobs Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution*; World Economic Forum: Cologny, Switzerland, 2016.
21. Sá, M.; Serpa, S. Transversal Competences: Their Importance and Learning Processes by Higher Education Students. *Educ. Sci.* **2018**, *8*, 126. [CrossRef]
22. Zamora-Polo, F.; Sánchez-Hernández, M.I.; Gallardo-Vázquez, D.; Hipólito-Ojalvo, F. Formando ciudadanos comprometidos. Fomento de la responsabilidad social en los universitarios. *Rev. Interuniv. Form. Profr.* **2014**, *28*, 51–62.
23. Kocaturk, T.; Kiviniemi, A. Challenges of Integrating BIM in Architectural Education. In Proceedings of the 31st eCAADe Conference, Delft, The Netherlands, 18–20 September 2013; Volume 2, pp. 465–474.
24. Eadie, R.; Browne, M.; Odeyinka, H.; McKeown, C.; McNiff, S. BIM implementation throughout the UK construction project lifecycle: An analysis. *Autom. Constr.* **2013**, *36*, 145–151. [CrossRef]
25. Wang, L.; Leite, F. Process-Oriented Approach of Teaching Building Information Modeling in Construction Management. *J. Prof. Issues Eng. Educ. Pract.* **2014**, *140*, 4014004. [CrossRef]
26. Wu, W.; Issa, R.R.A. BIM Education and Recruiting: Survey-Based Comparative Analysis of Issues, Perceptions, and Collaboration Opportunities. *J. Prof. Issues Eng. Educ. Pract.* **2014**, *140*, 04013014. [CrossRef]
27. Zhang, J.; Xie, H.; Li, H. Improvement of students problem-solving skills through project execution planning in civil engineering and construction management education. *Eng. Constr. Archit. Manag.* **2019**. ahead-of-print. [CrossRef]
28. Zhang, J.; Xie, H.; Schmidt, K.; Xia, B.; Li, H.; Skitmore, M. Integrated Experiential Learning–Based Framework to Facilitate Project Planning in Civil Engineering and Construction Management Courses. *J. Prof. Issues Eng. Educ. Pract.* **2019**, *145*, 05019005. [CrossRef]
29. Sánchez, A.; Gonzalez-Gaya, C.; Zulueta, P.; Sampaio, Z. Introduction of Building Information Modeling in Industrial Engineering Education: Students' Perception. *Appl. Sci.* **2019**, *9*, 3287. [CrossRef]
30. Sacks, R.; Pikas, E. Building Information Modeling Education for Construction Engineering and Management. I: Industry Requirements, State of the Art, and Gap Analysis. *J. Constr. Eng. Manag.* **2013**, *139*, 04013016. [CrossRef]
31. Uhm, M.; Lee, G.; Jeon, B. An analysis of BIM jobs and competencies based on the use of terms in the industry. *Autom. Constr.* **2017**, *81*, 67–98. [CrossRef]
32. Gnaur, D.; Svidt, K.; Thygesen, M.K. Developing students' collaborative skills in interdisciplinary learning environments. *Int. J. Eng. Educ.* **2015**, *31*, 257–266.
33. Sampaio, A.Z. The Introduction of the BIM Concept in Civil Engineering Curriculum. *Int. J. Eng. Educ.* **2015**, *33*, 302–315.
34. Sánchez-Martín, J.; Zamora-Polo, F.; Moreno-Losada, J. Including ethical learning and moral reasoning aspects in higher education: A proposal for developing ethical competences in the university. In *Business Intelligence, Strategies and Ethics*; Nova Science Publishers: Hauppauge, NY, USA, 2015; pp. 105–125. ISBN 9781634820646.

35. Dlouhá, J.; Pospíšilová, M. Education for Sustainable Development Goals in public debate: The importance of participatory research in reflecting and supporting the consultation process in developing a vision for Czech education. *J. Clean. Prod.* **2018**, *172*, 4314–4327. [CrossRef]
36. Nijhuis, S.; Vrijhoef, R.; Kessels, J. Tackling Project Management Competence Research. *Proj. Manag. J.* **2018**, *49*, 62–81. [CrossRef]
37. PMI. *A Guide to the Project Management Body of Knowledge (Pmbok Guide)*, 6th ed.; The Stationery Office Ltd.: London, UK, 2017; ISBN 9781628251845.
38. IPMA. *Individual Competence Baseline for Project Management*, 4th ed.; IPMA: Nijkerk, The Netherlands, 2015; ISBN 9789492338136.
39. Blanco Caballero, M.; Zulueta Pérez, P.; Alonso Fernández-Coppel, I.; Sánchez Lite, A. Implementation of BIM in the Subject Technical Industrial Projects—Degree in Industrial Technologies Engineering—University of Valladolid. In *Project Management and Engineering Research*; Springer: Berlin/Heidelberg, Germany, 2017; pp. 247–260.
40. Boeykens, S.; de Somer, P.; Klein, R.; Saey, R. Experiencing BIM Collaboration in Education. In Proceedings of the Computation Performance, 31st eCAADe Conference, Delft, The Netherlands, 18–20 September 2013; Volume 2, pp. 1–10.
41. Wu, W.; Hyatt, B. Experiential and Project-based Learning in BIM for Sustainable Living with Tiny Solar Houses. *Procedia Eng.* **2016**, *145*, 579–586. [CrossRef]
42. Leite, F. Project-based learning in a building information modeling for construction management course. *J. Inf. Technol. Constr.* **2016**, *21*, 164–176.
43. 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.
44. Pikas, E.; Sacks, R.; Hazzan, O. Building Information Modeling Education for Construction Engineering and Management. II: Procedures and Implementation Case Study. *J. Constr. Eng. Manag.* **2013**, *139*, 05013002. [CrossRef]
45. Wu, W.; Kaushik, I. A BIM-based educational gaming prototype for undergraduate research and education in design for sustainable aging. In *2015 Winter Simulation Conference (WSC)*; IEEE: Huntington Beach, CA, USA, 2015; pp. 1091–1102.
46. Baradi, K.; Oraee, M.; Hosseini, M.R.; Tivendale, L.; Pienaar, J. Teaching collaboration in tertiary BIM education: A review and analysis. In Proceedings of the Educating Building Professionals for the Future in the Globalised World, The 42nd Australasian Universities Building Education Association (AUBEA) 2018 Conference, Singapore, 26–28 September 2018; pp. 1–10.
47. Román, S.; Ledesma, B.; Alvarez, A.; Zamora, F.; Sabio, E. *Introduction to Project Based Learning on Engineering*; Nova Science Publishers: New York, NY, USA, 2015; ISBN 9781634822343.
48. Lee, N.; Dossick, C.S.; Foley, S.P. Guideline for Building Information Modeling in Construction Engineering and Management Education. *J. Prof. Issues Eng. Educ. Pract.* **2013**, *139*, 266–274. [CrossRef]
49. 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.* **2017**, *7*, 162–171.
50. Lassen, A.K.; Hjelseth, E.; Tollnes, T. Enhancing learning outcomes by introducing BIM in civil engineering studies—Experiences from a university college in Norway. *Int. J. Sustain. Dev. Plan.* **2018**, *13*, 62–72. [CrossRef]
51. 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. [CrossRef]
52. Novak, E.; Wisdom, S. Effects of 3D Printing Project-based Learning on Preservice Elementary Teachers' Science Attitudes, Science Content Knowledge, and Anxiety About Teaching Science. *J. Sci. Educ. Technol.* **2018**, *27*, 412–432. [CrossRef]
53. Muntaner-Mas, A.; Vidal-Conti, J.; Sesé, A.; Palou, P. Teaching skills, students' emotions, perceived control and academic achievement in university students: A SEM approach. *Teach. Teach. Educ.* **2017**, *67*, 1–8. [CrossRef]
54. 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. [CrossRef]

55. 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. [CrossRef]
56. Jeong, J.; Cañada-Cañada, F.; González-Gómez, D. The Study of Flipped-Classroom for Pre-Service Science Teachers. *Educ. Sci.* **2018**, *8*, 163. [CrossRef]
57. 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. [CrossRef]
58. 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. [CrossRef]
59. Zou, P.X.W.; Xu, X.; Jin, R.; Painting, N.; Li, B. AEC Students' Perceptions of BIM Practice at Swinburne University of Technology. *J. Prof. Issues Eng. Educ. Pract.* **2019**, *145*, 05019002. [CrossRef]
60. Yan, L.; Shirong, L. BIM Teaching Strategy for Surveying Students in China. *Int. Conf. Educ. Technol. Manag. Sci.* **2013**. [CrossRef]
61. Elinwa, U.K.; Agboola, O.P. Beyond BIM—A Classroom Approach To Virtual Design Education. *Procedia Soc. Behav. Sci.* **2013**, *83*, 393–397. [CrossRef]
62. Dillenbourg, P.; Schneider, D.; Synteta, P. Virtual Learning Environments. In *Information & Communication Technologies in Education*; Dimitracopoulou, A., Ed.; Kastaniotis Editions: Rhodes, Greece, 2002; pp. 3–18.
63. Prieto-Muriel, A.P. *Implantación de la Tecnología BIM en la asignatura Proyectos de los Grados de la Escuela de Ingenierías Industriales de la Universidad de Extremadura. Competencias Genéricas*; University of Extremadura: Badajoz, Spain, 2017.
64. 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 Divulg. Cienc.* **2015**, *12*, 550–564. [CrossRef]
65. 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. [CrossRef]
66. Zamora-Polo, F.; Sánchez-Martín, J.; Hipólito-Ojalvo, F.; Luque-Sendra, A. Utilización de la gamificación para el desarrollo de competencias transversales en el grado de Ingeniería Mecánica. In Proceedings of the 23rd International Congress On Project Engineering Management and Engineering, AEIPRO, Spain, 10–12 July 2019.
67. Lazzarini, B.; Pérez-Foguet, A.; Boni, A. Key characteristics of academics promoting Sustainable Human Development within engineering studies. *J. Clean. Prod.* **2018**, *188*, 237–252. [CrossRef]
68. Meng, M.; Peter, D.; Mattner, F.; Igel, C.; Kugler, C. Development and psychometric pilot-testing of a questionnaire for the evaluation of satisfaction with continuing education in infection control nurses. *Nurse Educ. Pract.* **2018**, *31*, 77–82. [CrossRef] [PubMed]
69. Ortega-Sánchez, D.; Gómez-Trigueros, I. Massive Open Online Courses in the Initial Training of Social Science Teachers: Experiences, Methodological Conceptions, and Technological Use for Sustainable Development. *Sustainability* **2019**, *11*, 578. [CrossRef]
70. Ferrandiz, J.; Fonseca, D.; Banawi, A. Mixed method assessment for BIM implementation in the AEC curriculum. In *Lecture Notes in Computer Science (including Subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*; Springer: Berlin/Heidelberg, Germany, 2016.
71. Reyes-Rodríguez, A.M.; García Sanz-Calcedo, J. Syllabus of Projects (2018/2019). Available online: https://drive.google.com/drive/folders/1fvPKr9QYtdBTgzHgE9JeudOhxlPJD1Es (accessed on 6 March 2019).
72. Autodesk Naviswork 2018 User Manual. Available online: https://knowledge.autodesk.com/support/navisworks-products/learn-explore/caas/CloudHelp/cloudhelp/2019/ENU/Navisworks/files/GUID-D1A18DA4-8246-41B8-8AEC-54DFD25B91F3-htm.html (accessed on 23 September 2019).
73. Autodesk Revit 2019 User Manual. Available online: http://help.autodesk.com/view/RVT/2018/ESP/?guid=GUID-DD8DF1E9-80B1-477C-BF98-E1BAD95060CA (accessed on 23 September 2019).
74. IBM. *SPSS 23.0. Developer's Guide*; IBM: Chicago, IL, USA, 2015.
75. Zarzycki, A. Considering Physicality in Digital Models. In Proceedings of the eCAADe2013, Delft, The Netherlands, 18–20 September 2013; pp. 425–434.

76. Vassigh, S.; Elias, A.; Ortega, F.R.; Davis, D.; Gallardo, G.; Alhaffar, H.; Borges, L.; Bernal, J.; Rishe, N.D. Integrating Building Information Modeling with Augmented Reality for Interdisciplinary Learning. In Proceedings of the 2016 IEEE International Symposium on Mixed and Augmented Reality (ISMAR-Adjunct), Merida, Mexico, 19–23 September 2016; pp. 260–261.
77. Lozano, R.; Merrill, M.; Sammalisto, K.; Ceulemans, K.; Lozano, F. Connecting Competences and Pedagogical Approaches for Sustainable Development in Higher Education: A Literature Review and Framework Proposal. *Sustainability* **2017**, *9*, 1889. [CrossRef]
78. Lewis Anderson, M.; Valdes-Vasquez, R.; Clevenger, C.; Shealy, T. BIM Energy Modeling: Case Study of a Teaching Module for Sustainable Design and Construction Courses. *J. Prof. Issues Eng. Educ. Pract.* **2015**, *141*, C5014005. [CrossRef]
79. Harari, Y.N. *21 Lessons for the 21st Century*; Random House: New York, NY, USA, 2018; ISBN 9781473554713.
80. Davidson, C.N. *The New Education: How to Revolutionize the University to Prepare Students for a World in Flux*; Hachette UK: New York, NY, USA, 2017; ISBN 9780465093183.
81. Kivunja, C. Teaching Students to Learn and to Work Well with 21st Century Skills: Unpacking the Career and Life Skills Domain of the New Learning Paradigm. *Int. J. High. Educ.* **2015**, *4*, 1–11. [CrossRef]
82. Lucas, J.D. Identifying Learning Objectives by Seeking a Balance between Student and Industry Expectations for Technology Exposure in Construction Education. *J. Prof. Issues Eng. Educ. Pract.* **2017**, *143*, 05016013. [CrossRef]
83. Macdonald, J.A.; Granroth, M. *Multidisciplinary AEC Education Utilising BIM/PLIM Tools and Processes*; Springer: Berlin/Heidelberg, Germany, 2013; pp. 663–674.
84. Bujacz, A.; Dunne, S.; Fink, D.; Gatej, A.R.; Karlsson, E.; Ruberti, V.; Wronska, M.K. Why do we enjoy creative tasks? Results from a multigroup randomized controlled study. *Think. Ski. Creat.* **2016**, *19*, 188–197. [CrossRef]
85. Jeong, J.S.; González-Gómez, D.; Cañada-Cañada, F. How does a flipped classroom course affect the affective domain toward science course? *Interact. Learn. Environ.* **2019**, 1–13. [CrossRef]
86. Jeong, J.S.; González-Gómez, D.; Cañada-Cañada, F. Prioritizing Elements of Science Education for Sustainable Development with the MCDA-FDEMATEL Method Using the Flipped E-Learning Scheme. *Sustainability* **2019**, *11*, 3079. [CrossRef]
87. Liu, R.; Hatipkarasulu, Y. Introducing building information modeling course into a newly developed construction program with various student backgrounds. In Proceedings of the 121st ASEE Annual Conference & Exposition, Indianapolis, IN, USA, 15–18 June 2014.
88. 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. [CrossRef]
89. Tomasowa, R. BIM design collaboration report: In student's perspective. In Proceedings of the CAADRIA 2015—20th International Conference on Computer-Aided Architectural Design Research in Asia: Emerging Experiences in the Past, Present and Future of Digital Architecture, Daegu, Korea, 20–22 May 2015; pp. 375–395.
90. Comiskey, D.; McKane, M.; Jaffrey, A.; Wilson, P.; Mordue, S. An analysis of data sharing platforms in multidisciplinary education. *Archit. Eng. Des. Manag.* **2017**, *13*, 244–261. [CrossRef]
91. Zhang, J.; Li, R.; Li, H.; Skitmore, M.; Ballesteros-Pérez, P. Improving the innovation ability of engineering students: A Science and Technology Innovation Community organisation network analysis. *Stud. High. Educ.* **2019**, 1–15. [CrossRef]