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PBL methodologies: BIM and 3D scanning applied to teaching in construction engineering projects

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Abstract - *The rising need among university graduates for technical education to achieve comprehensive, complete, and up-to-date training in the use of current technologies and advanced equipment, as well as the acquisition of skills related to collaborative abilities and the interrelationship between disciplines, requires the review of teaching and learning methodologies to university students. The current research includes the study carried out in a third-year subject of the Degree in Building at the University of Seville, on a total of eighty-two students, belonging to two academic years. It implements an innovative learning system, applying the principles of continuous assessment, encouraging collaborative work, participation in proposals, and the impact on their training resulting from their own experimentation with advanced technological equipment and BIM systems (Building Information Modelling) present in contemporary professional work, with verification of results, always following the PBL problem-solving-based learning method. The results of this study indicate that the understanding and implementation of the BIM methodology and the use of a 3D scanning tool, combined with the methodology based on the PBL are very useful for the development of projects in the field of building engineering. The data obtained after the surveys in relation to the students' assessment of their learning are very positive and a large majority of them state that after this course they have learned to work collaboratively, and it has helped them to overcome the fear of working with BIM and 3D scanning tools.*

Keywords – *learning, BIM, 3D laser scanner, higher education.*

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1. Introduction

The demands of the information society on university graduates, in the development of advanced skills and competences in the world of digitalization [1] are a fundamental factor to consider in the training process. One of the necessary keys to future success in the work of university technicians is the ability to work as part of a tea [2] and show aptitude and interest in using the right tools to optimize their results in the real world [3].

The University of Seville offers, in its third year of the Degree in Building, the subject "Technical Projects I", which aims to provide students with the tools and knowledge necessary to exercise the profession as an author and director of technical projects, within the scope of their professional skills, in accordance with the law on building management [4] and the Law on the attributions of technological architects and engineers [5] in the regulatory field of Spain.

On the other hand, this subject emerges from the opportunity that arises from the regulations for adaptation to the EHEA (European Higher Education Area), where European public universities are required to generate more participatory and democratic systems in higher education [6]. Therefore, it has been decided to implement an innovative learning system that combines various teaching methodologies, such as the principles of continuous assessment, the promotion of group work, participation and creativity in proposals, always following the learning method based on problem solving PBL [7], also applying the use of new technologies such as Building Information Modelling (hereinafter BIM), and advanced technological equipment such as 3D scanning and photogrammetry.

This article aims to answer the question of whether it is appropriate to introduce into PBL-based teaching methodology the use of advanced technological equipment such as 3D laser scanners, and their joint application with the new BIM (Building Information Modelling) systems currently being applied in building. At the end of the academic years, we evaluate the results we have obtained, not only through the analysis of the qualifications obtained, but also through a structured questionnaire to the students, which will allow us to extract data, results, and conclusions.

2. Research Methodology

El The survey was applied to all the members of the subject, Technical Projects I of the Degree in Building at the University of Seville. In the academic calendar, teaching is divided into three different groups. This is a subject belonging to the first term. The development of the second year of the survey has been conditioned by the COVID-19 pandemic. Despite this, the part of the course that introduced the use of the laser scanner could have been carried out face-to-face, while the second part of this course was developed on-line. In the two courses we both worked on the practical part of the training in the same area.

The use of a 3D laser scanner has been implemented to check the usefulness of the data obtained, applied to the new BIM systems in the Technical Building projects. The learning model focuses on the development and acquisition of competences and learning outcomes of students, the comprehensive and continuous assessment of student learning and the integration of problem-based learning (PBL), in addition to the introduction of new and existing collaborative data organisation and representation systems (BIM), together with the use of specific advanced technological equipment, present in the professional practice once they have completed their studies. In this way, it also responds to the previous expectations and perceptions of the students related to the development of their innovation and entrepreneurial skills, technology, engineering, and the practical state of work and professional prestige [8].

Problem- or project-based learning is successfully used in various professional disciplines and therefore we have proposed to use the same methodology in education in the field of architecture [9]. This learning system emerged in Denmark in the 1970s, when two new universities were opened in this country: Roskilde University in 1972 and the University of Aalborg in 1974. Both implemented new educational models, based on principles such as problem solving, project work, interdisciplinarity, learner-driven learning, and teamwork, in short, problem-based learning, a learning method based on the principle of using problems as a starting point for learning [10]. Therefore, we expect that the use of real-world problems (projects), combined with the promotion of active participation of students, integration of different points of view, teamwork [11] and the appropriate knowledge and use of new technologies and equipment, will lead to the improvement of the quality of education.

Assessment of student learning will be conducted continuously throughout the semester, and student feedback is an important part of learning acquisition. The methodology proposed to be developed in class is based on the following principles:

- Attitude for teamwork.
- Student participation during the practical classes, through public exposure of the proposals.
- Constructive criticism
- Active listening
- Brainstorming.
- Promote debate and public exposure to argue proposals.
- Optimization of the application of new technological systems and equipment in the project.
- Knowledge and implementation of innovative and optimal solutions in the preparation and presentation of project documentation.

The didactic intervention in the classroom will focus on the use of methodologies that encourage the participation of students in the learning process and help them to develop strategies to continue learning throughout their lives. Student participation and interrelationship can be enhanced by digital technology, which has become a central aspect of higher education [12]. Principles of learning in problem solving such as focus groups, teaching through assessments in various formats, mentoring workshops, classroom questionnaires, etc. will be encouraged. [11]. This type of learning methodologies requires certain changes in the traditional modus operandi of the main agents in the teaching-learning process, i.e., the teacher and the student.

We must realize that today's university students can be considered "digital natives" [13], and the educator becomes the facilitator and integrator of the student in his or her learning process, always guiding the student in the application of these digital resources, to achieve the intended teaching objectives, encouraging the spirit of self-criticism and improvement, as well as the desire to acquire knowledge and the ability to work in teams.

In the student-centred approach to teaching, the main roles of the instructor should be as a guide and facilitator to share information with students and support creativity [2]. At the same time, the lecturer is the expert who resolves doubts, clarifies processes, guides the student always in learning, although the lecturer must make the previous effort to acquire the knowledge and develop the integration of new technologies and equipment in the subject in question [14].

This methodology allows us to generate appropriate environments or atmospheres to stimulate students' initiative and freedom of opinion, as can be seen in the functional diagram of the subject exposed in Figure 1.

In This way, students generate a positive attitude towards learning and research, becoming aware of their own learning objectives.

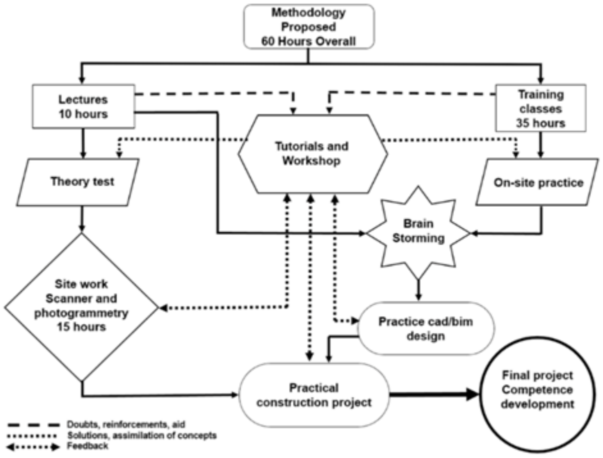

Figure 1. Functional diagram of the methodology proposed in the subject Technical Projects 1

On the other hand, it encourages the oral presentation of the projects of the different groups of students in front of their own peers and in the active presence of the teacher who always guides, corrects, or inspires new solutions. This, in turn, should not exclusively take an instrumental approach to technology [15], but should favour the use of this technology applied to real-world problems, encouraging the active participation of students, the integration of different points of view, the promotion of self-oriented learning, the encouragement of team collaboration, links with current scientific findings, and the improvement of the quality of education.

Pedagogical aspects on which this methodology, based on the use of PBL, focuses are the following:

2.1 Group-based learning

Most learning processes are carried out in groups and teams. Implicitly also the development of personal skills. In the relationship between theory and practice where students learn to relate concrete or empirical experiences to theoretical ones.

The ability to relate theory to practice is a decisive aspect in the application of knowledge and especially in the competence of analysis. The solution to problems must be accompanied by a multidisciplinary approach to the problem based on the specific contribution of each team member, according to their specialization.

Activity-based learning is a central part of PBL's learning processes, as it requires the performance of an activity that is solved through the processes of research, decision-making, and writing and drawing. In our specific case, it involves the integral development of a Technical Project, which includes the phases described in Figure 2 below.

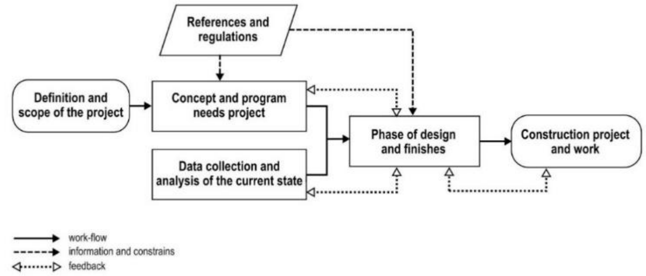

Figure 2. Working phases of the project development

Work groups are generated while students analyse the proposed projects. Working in collaborative groups, develops reflective thinking, stimulates the formulation of different opinions, and develops respect and tolerance for other student's opinions [16]. The teacher's role is to facilitate the students' learning process, that is, to encourage the work and internal communication of the group, becoming supervisors, facilitators, and community mediators. Students normally prefer to generate their own work group, as they believe that they can obtain better results if they can select their teammates, instead of being grouped at random by the teacher or facilitator [17], favouring a sense of responsibility and integration.

Through this system of learning, students are given the opportunity to reflect on their knowledge in relation to the new situations they face in a complex and global world [18]. Students are no longer passive. In the study group, each student presents his or her work and it is discussed so that the group can contribute ideas and constructive criticism. Several studies reflect that the PBL methodology contributes to changing students' passive learning routines towards more active and responsible learning [19].

2.2 Brainstorming

This technique was created more than 60 years ago to help groups of people generate ideas [20]. By using rules that remove inhibitions, people can think more freely and create new ideas and solutions. Students contribute ideas as they occur to them and then build on the ideas put forward by others to in turn generate new ideas. All ideas are noted and not discussed.

This brainstorming tool, we focused on the following aspects:

All ideas are potentially good. At this stage, avoid discussing ideas, as this inevitably involves criticizing or congratulating them. So, do not judge the ideas until the process is over. An active learning method with for the student to enhance creativity in multiple disciplines [21].

Encouraging new, innovative, and even exaggerated ideas. The riskier the idea, the better it looks initially. No idea is, a priori, too ridiculous, or extravagant. The riskier the idea seems, the better at this stage of the learning process. Much of the exchange of ideas and experiences among students occurs informally in this period [22].

The quantity of ideas contributed counts at this stage, not the quality. It is better to focus on the quantity of ideas at this stage, to encourage participation, and to narrow down the list later. All activities should be geared towards extracting as many ideas as possible in each period. The most creative ideas of a person or a group should be chosen from many of them. If the number of ideas at the end of the session is very large, there is a greater chance of finding a very good idea.

Build on ideas submitted by others. Build on and expand on the ideas of others. Use other people's ideas as inspiration for others. Creative people are also good listeners. It is as valuable to be able to generate a new idea as it is to adapt and improve on the ideas of others, since it is the generation of the initial idea that releases new lines of thought.

They can also draw sketches or hand-drawn outlines to generate new ideas to help them communicate and understand complex ideas, as well as react quickly during discussions with other members of the project or collaborative group. This helps students to achieve higher thinking and to be more creative in solving complex problems [23].

Every person and every idea have the same value. Each person has a valid point of view and a unique perspective on the situation and the solution. Everyone should be encouraged to participate. It is the responsibility of the group and an indication of their ability to exchange ideas if all participants feel they can contribute freely and confidently.

2.3 Encouraging debate and public exposure to argue proposals

Furthermore, the debate and public presentation by groups of students to argue proposals for optimised application of new technological systems allows students to learn from each other. One of the main tasks of the facilitators is to promote debate within and outside the groups. Efforts should be conducted in such a way that the proposals end up being new and innovative. Innovation must be encouraged, as students must be made to explore new ideas and solutions [24], especially when they are faced with new technological challenges.

2.4 Promotion for innovative solutions

This encouragement of the search for innovative solutions promotes excellence in the preparation and presentation of the graphic documentation of the technical project. Learning problems should be complex and not have a single solution. They must be flexible and allow for different approaches. Innovation favours the development of forms of joint activity for teachers and students, promoting autonomy, self-regulation of student learning and encouraging the use of collaborative work as a fundamental educational tool for student learning [25]. The final solution lies in discussion, alternative tests, failure and success, improvement, and correction of previous solutions, instead of finding solutions in a direct and unique way. Innovation must be encouraged, as students must be made to explore new ideas and solutions [8].

2.5 Implementing BIM technology and 3D scanning

Finally, the analysis and application of new graphic representation procedures based on BIM systems have numerous advantages in the university training of architects and building engineers [26] especially if it is related as real-world based learning to completed projects, increasing student motivation in understanding the associated content [27] and providing teachers with the opportunity to learn and apply the specific technologies needed in each field [28].

Students are initially faced with the problem of the transition from 2D drawing to parameterized modelling and the restrictions that affect the quality of the elements to be developed [29], so they immediately value the use of the BIM system and associate it with an improvement in their work efficiency and the timeliness of the systems used professionally, generating greater motivation in learning and satisfaction in their use [30]. In addition, the BIM methodology implies the concept of centralised information in a unique geometric model that promotes collaboration between all those involved [31].

If in addition we add the use of technological equipment to obtain geometries of existing buildings by means of 3D laser scanning [32], the organisational and collaborative challenge arises, given the extent of existing 3D scanning methodologies and the technologies proposed in the existing industrial scientific literature [33].

The advantages that the use of 3D scanning brings to the process flow for existing buildings that allows to support the design in sustainability, time saving and accuracy for the subsequent verification of the BIM model made, are widely documented [34]. Students are offered to use Autodesk Revit software in its educational version to obtain the final three-dimensional model, and are given the use of a Leica BLK 360 3D laser scanner as innovative technological equipment, which allows them to obtain a cloud of points that serve as a reference in modelling [35], and to visualise discrepancies between projects-reality, with the creation of information repositories where they can store and review the evolution of the building over its lifetime [36]. As they become aware of the benefits of these systems, which have enormous technical and visual appeal and are very up to date, the students themselves investigate procedures and characteristics to optimise their application.

3. Results

3.1 3D scanning and point cloud

In the case of study, the students choose the composition and number of participants in the groups (3 or 4), for data collection in the field work using the Leica BLK360 scanner, which will provide a point cloud that in turn requires the use of specific editing software for optimization. Because of the full compatibility of Autodesk software (Revit and Recap Pro) and its free distribution in its educational version, students were initially given the opportunity to download and install Autodesk Recap Pro. The students decide on the location of equipment, the number of them necessary to obtain solutions, and carry out the subsequent unification (registration), as can be seen in Figure 3.

Roles are distributed and a self-critical spirit appears in the exchange with other groups in the proposed solutions. Finally, individual confidence and the importance of group integration are reinforced.

In this first phase a global point cloud is obtained that allows the student to digitally perceive volumes and spaces that he associates with the existing volumes [37]. New possibilities and associations with other innovative and current technologies appear, such as geo-positioning, photogrammetry, augmented reality, simulation, etc.

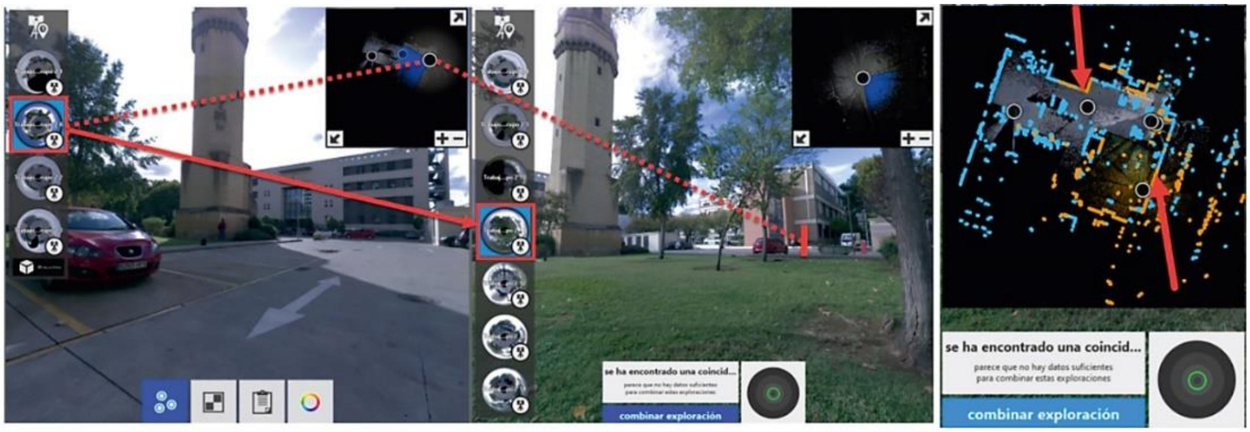

Figure 3. Working phases of the project development

Figure 4. 3D point cloud developed in class practice. Academic year 2019/20

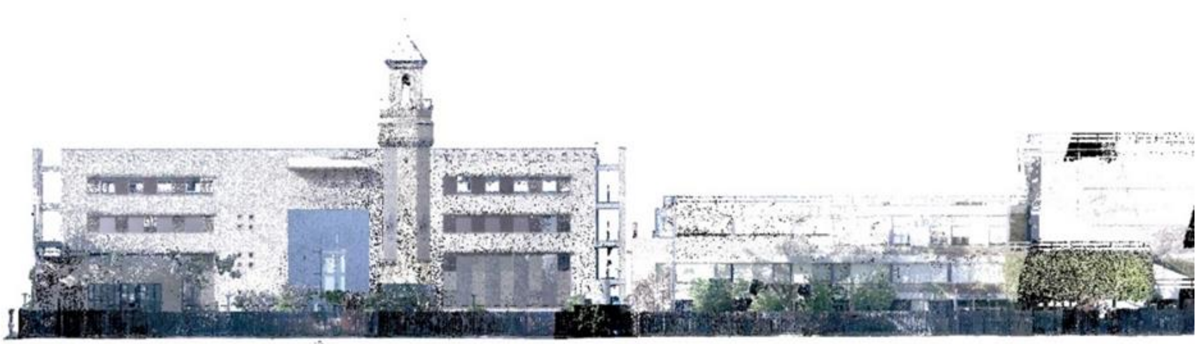

Figure 5. Elevation of the real point cloud made in class practice. Academic year 2019/20

The point cloud editing software is installed in conjunction with another application that also allows point clouds to be obtained by photogrammetry: Autodesk Recap Photo.

Photogrammetry allows them to obtain 3D points that generate geometric volumes by means of photographs [38], which are made following appropriate criteria in the image making phase [30], universalizing the use of this technology, as it can even be made with smartphones with a good optical quality in their integrated camera. This encourages students to investigate these techniques without the need for high-cost equipment and to analyse the suitability of methodologies according to the desired result, verifying that in the case of heritage buildings, photogrammetry is also a widely used technique combined with the use of 3D scanners [39], [40].

Afterwards, they were given the opportunity to download and install the Revit software, to insert the point cloud optimised in Recap Pro, and to have a reference in the creation of conceptual masses, facilitating the perception of the integration with the already existing volumes, of the architectural design elements provided as solutions. This virtual capacity for global perception encourages creativity. The final models obtained are very interesting, as can be seen in the figures below, in which proposals have been made to adapt the exterior common areas to the existing buildings.

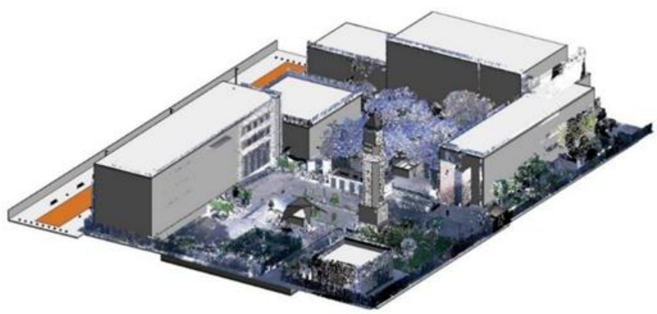

Figure 6. View of project proposal of intervention inserted in point cloud by students of Technical Projects 1. Source: Class practice academic year 2019/20 (C. Delgado Cobo).

Figure 7. Final 3D presentation by students of Technical Projects 1. Source: Class practice academic year 2020/2021 (T. Buzón Martínez and M. Lope Mariscal).

Figure 8. View of project proposal of intervention inserted in point cloud by students of Technical Projects 1. Source: Class practice academic year 2019/20 (C. Delgado Cobo).

To determine the level of personal satisfaction with the methodology developed, at the end of the courses a survey was carried out on all the members of the subject. The total sample of students surveyed is 82 belonging to the first academic year, 2019/20, structured in three groups of 17, 15 and 16 students respectively, and the next one 2020/21, also in three groups of 17, 8 and 9. Figure 4, 5, 6, 7, 8.

This survey has three blocks of questions adjusted to the time frame: before, during and after the experience followed with the implementation throughout the classes of this combined methodology. The results are collected in the following graphs, which are presented in the following sections.

3.2 Specific knowledge before the beginning of the course

In this block of questions, the students are asked about the knowledge and skills they had before the beginning of the teaching in this subject, in relation to the BIM methodology and the 3D scanning, both by subjects and previous projects. Those respondents who answer positively regarding having had previous knowledge through previous subjects are asked to indicate that previous subject. Figure 9 and 10.

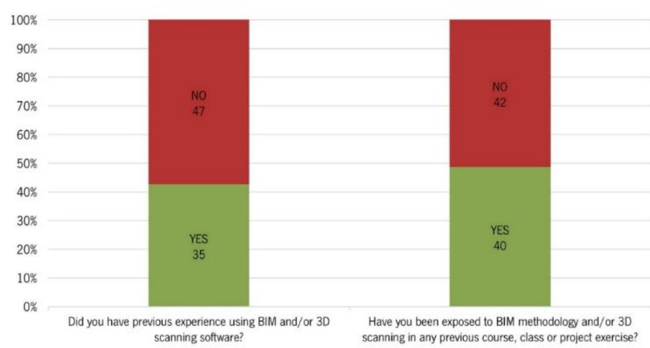

Figure 9. Experience and background. Academic years 2019/20 and 2020/21)

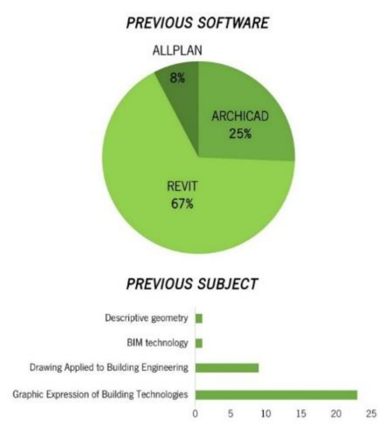

Figure 10. Knowledge of the student in 3D tools before the beginning of the course and subjects related. Academic years 2019/20 and 2020/21).

3.3 Expectations before starting the training course

At the beginning of the course, students are consulted about their previous expectations in relation to the acquisition of knowledge and the training and practice with new technologies applied to the graphic representation in BIM and 3D scanning. Figure 11.

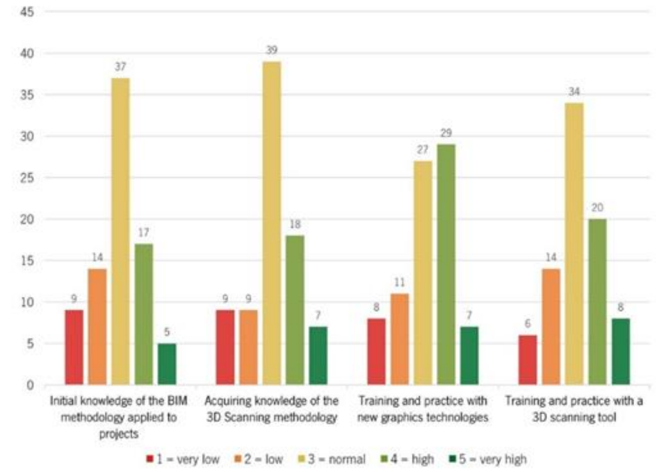

Figure 11. Expectations for this course. Academic years 2019/20 and 2020/21. Source: Own elaboration.

3.4 Considerations during the development of the course

Once the training session has started and before beginning to work with the students in the project, they are asked about their impressions about the group work, taking into account their appreciations regarding the organization of the group, that is, if they consider that the roles and responsibilities of the different components of the group were well defined, if the tasks were well organized and who developed them, if a leader was designated and if the meetings to follow up the work were scheduled. Figure 12.

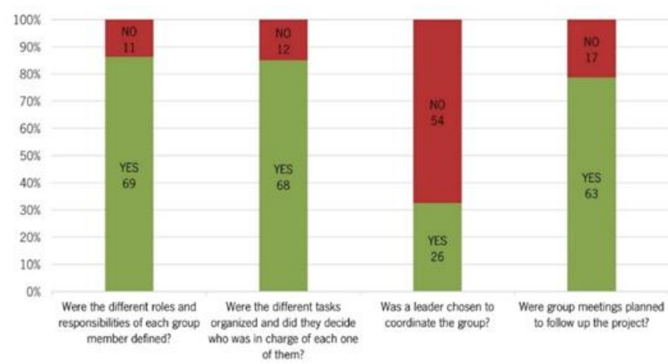

Figure 12. Considerations before beginning work. Academic years 2019/20 and 2020/21. Source: Own elaboration.

3.5 Level of difficulty during the development of the project

Through this block of questions, several issues are consulted about the difficulties they have had during the development of the project, such as the communication between the different members of the group, the information exchange management, if the software has been simple and intuitive for them, the trust, compromise, effectiveness, and collaboration between the different participants of the group. This battery of questions is the most important body of the survey and the one that will allow to draw clearer conclusions regarding the experimental methodology carried out during the development of the project. Figure 13.

During the course, the students have developed the tools defined in this study, both in teamwork, new technologies, the PBL methodology, among others, so the opinion they can provide us in relation to their experience and perceptions is very important for us.

This section is structured in 5 questions that ask the students their evaluation about the communication between the members of their group, the facility or not that they have had at the time of exchanging information, such as files, drawings, or plans. If they have had difficulties with the development of the new software, or if they have found it intuitive and simple.

It has also been considered of high interest to ask them about their perception regarding various aspects of their working relationship with the group, such as trust, participation, commitment, and effectiveness of the collaborative work done.

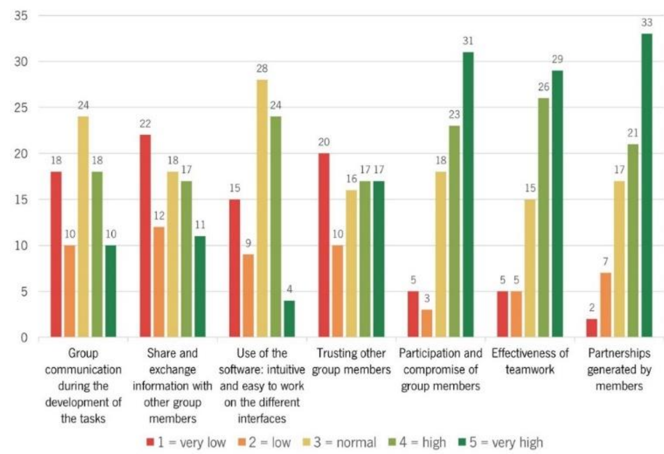

Figure 13. Level of difficulty during project development. Academic years 2019/20 and 2020/21. Source: Own elaboration.

3.6 Assessment of the level of support provided by the training course

In this section the student is consulted regarding his personal evaluation of the understanding and implementation of new technologies and BIM methodology, as well as the level of understanding and use of 3D scanning tools. Figure 14.

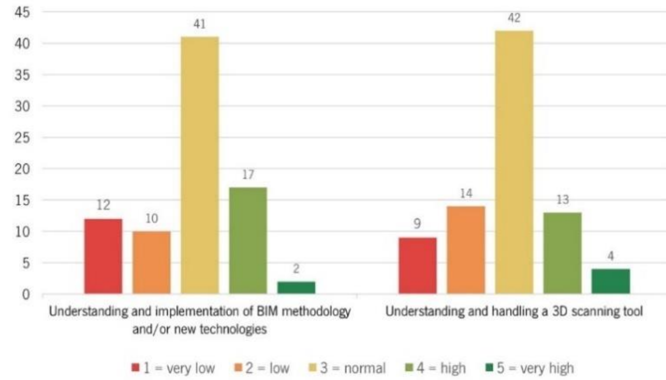

Figure 14. Level of support provided by the course. Academic years 2019/20 and 2020/21. Source: Own elaboration.

3.7 Perception of the satisfaction level of the course

The student is asked a set of questions that aim to measure his level of satisfaction with the course at its end, in relation to the following aspects: his perception of teamwork, the acquisition of knowledge about new technologies for building surveying, practical training with a scanning tool, as well as the support received during theoretical and practical training in the laboratory. Figure 15.

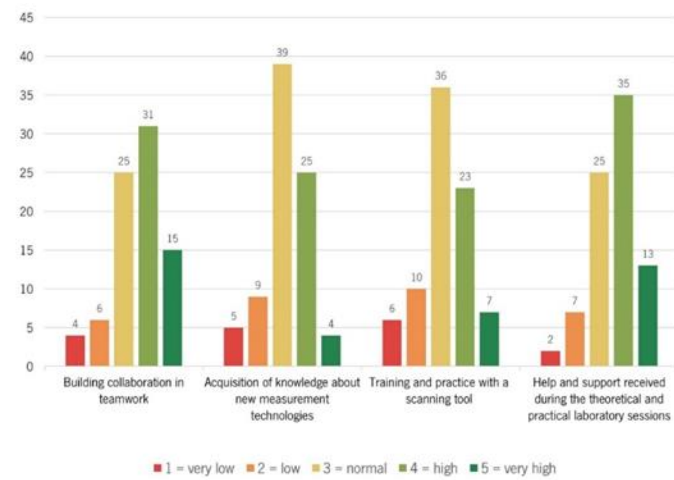

Figure 15. Level of satisfaction with the training course. Academic years 2019/20 and 2020/21. Source: Own elaboration.

3.8 Overall assessment of learning

Once the course has been completed and the project developed, in accordance with the methodologies set out above, the student is consulted about the overall assessment of the project, focusing on four specific aspects.

First, it is an important objective for us to test the students in the development of the tools in the collaborative work and to know their degree of satisfaction regarding the group works.

Secondly, we are interested in knowing the students' perception of the new technologies and thus to know if, at least, they have been able to lose a little fear of the implementation of 3D scanning and BIM methodology.

Thirdly, for their future professional practice, we consider it interesting to know if, after the development of the project, they have expectations of handling these new tools. Finally, we ask them if, from now on, they are considering the use of the BIM methodology and 3D scanning in future projects. Figure 16.

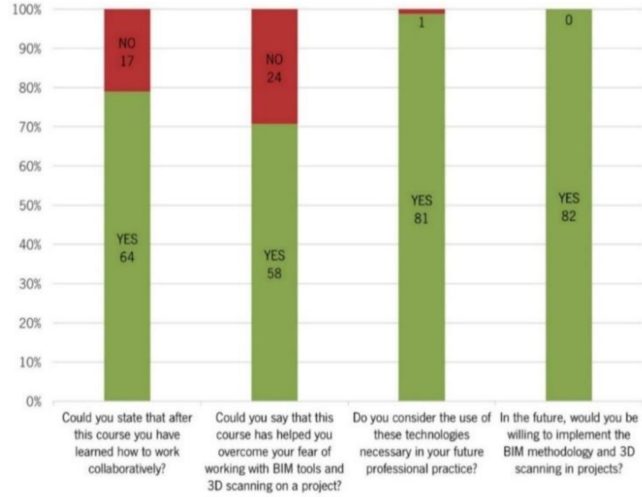

Figure 16. Overall assessment of learning after the course. Academic years 2019/20 and 2020/21. Source: Own elaboration.

3.9 Comparison of results with previous courses

The results obtained by applying this teaching methodology, after the end of the corresponding academic period, can be considered favourable, not only from the point of view of the significant increase that occurs in the pass rate, remarkable and outstanding, but in the integral training of the student in engineering studies, in a specialized and interdisciplinary way. The greater participation of students in class activities and projects has resulted in a better appreciation of their personal work with respect to the group, intervening in a more active way and, in short, with a greater commitment to the objectives of the subject, which allows them to develop their own skills. Figure 17.

Figure 17. Comparison of academic years 2017/18, 2018/19, 2019/20 and 2020/21 results. Source: University of Seville.

The variation in the results indexes with respect to previous courses shows a substantial improvement. In the academic year 2019/20 the percentage of students who obtained high marks, i.e., marks, honours and outstanding, was 41%, compared to 26% in the academic year 2018-2019 and 23% in the academic year 2017/18. The results of the 2020/21 academic year show a considerable increase in the number of students who have passed the course compared to previous years, as shown in Figure 17.

4. Conclusions

From the detailed analysis of the data obtained through the student surveys at the end of the course, the following can be deduced:

- 42.68% of the students surveyed had some previous experience with BIM methodology software, specifically 67% with Revit, 25% with ArchiCAD and 8% with Allplan.
- Almost half of them, 48.78% have had some previous experience in BIM in previous subjects, specifically in the subject "Graphic Expression of Building Technologies", of second year, followed by " Drawing Applied to Building Engineering", which is taught in the first year of the degree.
- In relation to the previous expectations that the students have before the beginning of the course with this combined methodology proposed is, in general, high, since 65,85% of the total of them declare to have medium and high expectations regarding the acquisition of initial knowledge on the BIM methodology applied to projects and 69.51% regarding the acquisition of knowledge of 3D scanning. Likewise, the previous expectations are high regarding training and practice with new technologies of graphic representation and 3D scanning. Specifically, 67.07% of the total students surveyed have medium and high expectations.
- Regarding the collaborative work, the answers of the students in general have been very positive, since 86.25% have answered affirmatively to the question of whether the different roles and responsibilities of each member of the group were defined, 85.00% have also answered positively to the question of whether the different tasks were organized and decided who was in charge of each one of them and 78.75% have also answered affirmatively to the question of whether the group meetings for the follow-up of the project were planned. However, to the question of whether a leader was conveniently chosen for each group, the answer has been negative by 67.50%, so this indicator reveals the need to improve this aspect in future courses.
- In relation to the perception of the development of the course, the students indicate the following: the communication between the members of the group during the development of the tasks has been between normal and very high for 65.00% of them. More than half of the participants, specifically 57.50%, have not had difficulties in sharing and exchanging information with other members of the group. Similarly, when asked if they had difficulties with the use of the software, 70.00% indicated that they found it intuitive and easy to work with the different interfaces. Regarding the relations with the group, 62.50% of the students surveyed reported that they were able to trust other members of the group. However, it is interesting to note that 25.00% of them recognise that

they have not been able to trust the team, a figure that will have to be worked on to improve it in subsequent courses. Regarding the participation and commitment of the group members, the survey reveals a very encouraging figure, with 90.00% answering in the affirmative. Equally interesting is the response of the students who, when asked about the effectiveness of joint teamwork, answered positively by 87.50% of them. Finally, 88.75% responded affirmatively to the consultation made regarding their perception of whether the collaboration generated among the members of the group was favourable or not. This set of questions presents, globally, a favourable scenario with respect to the possible difficulties that the students could have had during the development of the course under these methodologies proposed in this study.

– The answers obtained, after the course, regarding the evaluation of the level of help provided after the course, the students also answer quite favourably, since 72.56% respond positively regarding the understanding and implementation of the BIM methodology and the handling of a 3D scanning tool.

– The results obtained related to the general satisfaction of the course are very favourable, being structured as follows: 87.65% answer positively regarding the establishment of new methodologies in relation to the collaboration in team work, 82.93% answer positively regarding the acquisition of knowledge about new surveying technologies, 80.49% regarding the training and practice obtained with a scanning tool and 89.02% regarding the help and support received during the theoretical and practical laboratory sessions.

– Finally, the data obtained after the survey in relation to the students' overall assessment of their learning are very positive. 79.01% of the students say that after this course they have learned how to work collaboratively, 70.73% say that this course has helped them to overcome their fear of working with BIM tools and 3D scanning in a project, 98.78% consider the use of these technologies necessary in their future professional practice and, finally, 100% of the students surveyed say that they would be willing to carry out the implementation of the BIM methodology and 3D scanning in future projects.

As a general assessment of the results, one of the first conclusions of this study is that academic results have greatly improved, both in the degree of student satisfaction and in the academic efficiency rates obtained. However, it should be noted that the performance in the first weeks of the course was lower due to the initial difficulty of the knowledge and application of both the BIM system and the equipment, although the degree of interest shown by the students overcame these initial difficulties from the fourth week onwards. It is also possible to highlight as an important conclusion to be considered that, through this methodology, discussion and group work dynamics are generated with the students that expand their personal skills, especially those related to communication, as well as favouring collaborative work.

Furthermore, the first approach of the students to the use of new systems and technological equipment related to the subjects they study presents advantages if it is in a group, since they are the ones who adapt the new systems to their own native digital culture. This, in turn, implies that teachers must make a previous effort to adapt these new systems to their own digital training, researching all the advances in vanguard, analysing advantages and disadvantages, to offer them as application options in the training of their students.

Another important aspect to emphasize is the satisfaction perceived by the students when they see that they are developing avant-garde techniques, which they will be able to apply later in their professional work. Therefore, this experience may conclude that, in order to achieve better academic results, it is essential not only to provide adequate space and physical facilities, such as, in this case, computers with sufficient capacity, BIM software, scanners and cameras for photogrammetry, but it is also necessary for university teachers to adapt their training to the new digital technological systems and equipment related to their field, in order to work as teachers in a gradual change and constant renewal of traditional forms of education.

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