BIM Education Experience in Social Project Resolution with User Evaluation

International Architecture Workshop ETSAB-UPC, UAM-Azc, ETSALS-URL

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Abstract. This article is the continuation of the research published in WorldCist 2020 under the topic "L) Information technologies in education", which describes the educational results of the implementation of Building Information Modeling (BIM) systems in an inter-university workshop. The purpose consists in a real case study in which experiences are observed and evaluated. The main objective is to encourage and improve the preparation of students in the use of information and communication technologies (ICT) and BIM methodologies. These skills that must be developed to face the transformations of the construction sector. The participants were 27 students from the *Universidad Autónoma Metropolitana Azcapotzalco* (UAM-Azc), the *Escuela Técnica Superior de Arquitectura de Barcelona* (ETSAB) and the *Escuela Técnica Superior de Arquitectura La Salle* (URL). These students participated in the "1st International BIM Workshop on the Resolution of Social Projects 2020", to carry out a preliminary project of urban equipment in Mexico City (CDMX). The activity was focused into exploring the use of virtual environments, applying the BIM methodology and bringing students closer to scenarios committed to social reality. The evaluation of the user experience was performed with a quantitative survey. The results showed a favorable adoption of BIM systems. The main contribution of the article is the validation of educational methodologies through enhanced learning with technology. This study also aims to be the first stage of academic interoperability between the universities ETSAB-UPC, La Salle URL and UAM Azc.

Keywords: Building Information Modeling, User Experience, BIM Education, Virtual Collaboration, Architecture Workshop, Project Based Learning

1 Introduction

The importance of BIM, as a research topic, lies in the gradual incorporation of this methodology into the university curriculum. This will allow it to recognize its educational and didactic benefits and to find mechanisms that favor the labor opportunities of the graduates. There are several empirical researches in BIM education with favorable results in terms of student motivation and satisfaction (Ferrandiz, Fonseca & Banawi, 2016) (Bernal & Rodriguez, 2018) (León & Pérez, 2018) (Shults, 2019) (Besné, Fonseca & Navarro, 2020). In addition, students affirm the usefulness of BIM to develop their projects faster and in a better way (Ferrandiz, Banawi & Peña, 2018). Another study (Jin, Xiaowei, Li, Piroozfar & Painting, 2019) reveals that students have the perception that BIM will allow them to be better prepared when they graduate.

The fragmentation of the construction sector is obvious and the introduction of BIM has further challenged these systems (Shafiq, Matthews, & Lockley, 2013). Thus, from the academy, models must be promoted that extend the current disciplinary collaboration towards the multidisciplinary one. Training future architects in collaborative skills is critical to their professional success. BIM education should not be limited to the application of tools, it should also focus on the benefits of collaboration. According to previous research (Ferrandiz et al., 2017) BIM, is a fully collaborative environment that easily allows universal access to information. In this regard, other studies on BIM implementation have shown that collaborative work facilitated by ICT enriches learning (Marcos, 2017) (Suwal & Singh, 2018) (Jin et al., 2019).

The experiential learning with content committed to social realities is a relevant aspect in the training of students in higher education. Research results shows that the implementation of methods of Project Based Learning (PBL) motivates users and helps them understand the challenges of the industry (Navarro et al., 2012) (Sánchez, Redondo, Fonseca & Navarro, 2014) (Fonseca, et al., 2017) (Zhang, Xie & Li, 2018) (Fonseca et al., 2020). PBL effectively influences students' critical thinking and problem-solving skills (Tsai, Chen, & Chang, 2019). Integrating BIM education and PBL pedagogy provides a solid foundation for teaching architecture because it can provide a planning framework for teaching.

The implementation of BIM in Higher Education Institutions (HEIs) must also be a strategic decision to improve institutional competitiveness and the validity of the degree. Therefore, BIM requires up-to-date teaching. Academic institutions cannot be unaware of the digitalization of the profession, this adaptation has to minimize efforts and learn to collaborate, not only with the academic community, but with industry, government and society. Therefore, this Workshop sought to create a digital space that would arouse the interest of teachers and enhance student learning, but also, to encourage rapprochement and exchange between society and academia, in a shared learning process. Assessing participants' experiences, especially perceptions and motivations, will help to promote BIM and its benefits for teaching, on a path to inclusion in the university curriculum.

1.1 Study Case

The School of Architecture of Barcelona (ETSAB-UPC, Spain), the School of Architecture of La Salle (ETSALS-URL, Spain) and the Universidad Autónoma Metropolitana Azcapotzalco (UAM Azcapotzalco, Mexico), in early 2020, collaborated to promote new forms of interaction in virtual environments and highlight the benefits of BIM education with real projects. In this way, with the First International BIM Workshop, students, teachers and professionals from the three institutions joined forces to resolve in two weeks the preliminary design of a public healthcare equipment in a community with little access to these services.

The workshop was held in the facilities of the Architectural Representation Center of the Department of Architectural Representation (ETSAB-UPC) and in the Department of Research and Knowledge of the Division of Sciences and Arts for Design (UAM). The online interaction between the three higher education institutions sought to enhance learning through reflection, collaboration, awareness and dialogue. Teachers focused on the observation, analysis, and interpretation of the virtual interaction. Students participated in creative processes with parametric modeling programs such as Revit. They also had different resources and the guidance of BIM professionals to make proposals in response to the needs of the community Santa Isabel Tola, Gustavo A. Madero, CDMX. Students, teachers and industry professionals exchanged information in online video meetings. The 40 participants had essential documentation and resources that were hosted in the cloud. Throughout the day, the specialists offered an overview of the digital transformation of the sector and provided critical reflection on the profession and its involvement in the social context. Students also attended free training seminars previously to the workshop given by Dr. Isidro Navarro.

The dynamic consisted of forming interuniversity teams and assigning job profiles to each member according to their skills in advanced technological tools. Roles were established so that everyone could face the complexities of the digital information management process and experience the basic principles, procedures and tools of BIM. Although difficulties arose due to the physical-temporal separation and cultural differences, the students generated 4 architectural proposals. According to the diagnostic pre-test (Sandoval, Delgado & Sandoval, 2020), only 20% knew some BIM concepts or tools previously. So, they were not required to have a high level of project development, but they did need to demonstrate basic technological and collaborative skills. In addition, the social purpose of the workshop had to be met, to give architectural answers in favor of local development.

2 Methodology

The survey was applied at the UAM - Azcapotzalco to two groups of 7th and 9th term (3rd year of bachelor's degree) in the subjects of Architectural Design Workshop IA and II-A, during week 7 of the 19-O quarter (autumn 2019). Fourth-year students from ETSAB-UPC and La Salle ETSALS-URL also participated. A total of 27 students from the three architecture schools performed the post-test. It should be clarified that for this

first experience a series of logistical difficulties arose. The main one, to reconcile dates of implementation between institutions with different academic periods (quarterly and semester) and time zones. The user experience was evaluated with a quantitative post-test. The aim of the test is to record the perception of the participants of the First BIM International Workshop on the experiences, motivation, satisfaction and learning obtained. The specific objectives were to evaluate: a) the explanatory method of the workshop, b) the difficulties of organization and teamwork, c) the level of motivation to learn BIM methodology, d) the perception of the benefits that BIM represents for the student, e) the perception at the level of BIM knowledge and skills.

To achieve the objectives, a series of questions were designed divided into 4 blocks: 1) workshop assessment, 2) BIM comprehension, 3) acquired knowledge and 4) development and use of BIM. The first block of the survey focused on the competencies achieved in the training course, the second presents the concept of BIM from the student, the third assessed the knowledge bases and the fourth focused on knowing the experiences of participants with the application of BIM.

3 Results

The questionnaire is not integrated into the article due to its length limits, however, some of the questions are included and developed in this section. The following are the most significant results of the survey, starting with the description of the system for data collection, structure and population:

- Data collection system: Anonymous questionnaire distributed via institutional mail through the Google Forms tool.
- Description of the structure: The questionnaire consisted of 21 questions divided into 4 blocks. The first of them contained 6 closed questions; a dichotomous or exclusive, 4 on the Likert scale of 5 categories, where students had to indicate the degree of concordance with the proposed statements, being 1 "low" and 5 "high" and an enunciative question. The second block presents an open-ended question for the purpose of registering the participant's BIM definition. It also consists of 5 statements in which participants assess the BIM knowledge achieved on the Likert scale. The third block presents 6 questions with the same scale, which deepen the level of knowledge achieved depending on the content. Finally, block 4 presents 3 closed questions, where participants express their assessment of BIM based on the experiences lived in the workshop.
- Population: The profile of the assistant is between 21 and 31 years, being more than 60% students between 21 and 24 years. 71% are male and 29% female. It was a heterogeneous group in terms of nationalities. 24 students from Mexico participated, 2 from Spain, 1 from Mauritania and 1 from Iran. 62.5% conducted the workshop in its eighth quarter, compared to 37.5% in tenth. Most attendees say this is their first time attending a BIM workshop. Only 12.5% say it is not the first time.

Block 1: Evaluation of the workshop. The first section of the survey sought to know the participants' assessment of the explanatory method and the difficulties of working

as a team. This section consisted of 4 reagents with forced response option (only one possible). Each answer was assigned a score based on the Likert method, on a rating of 1 to 5, where 1 is ‘low’ and 5 is ‘high’.

- Attendees evaluated the workshop's explanatory method with a 4, followed by a 3, highlighting a lower percentage on a 5.
- Something similar happens in terms of the difficulty of organization and teamwork. With the same score and emphasizing on the rest their ratings are 3 or 4.
- As for the role they played, there are various answers, including the most repeated ones such as the design, rendering and organization of data or tasks.
- 62.5% responded with the highest score to the degree of attractiveness of the Revit software. The same number of attendees opted for the same score in terms of their degree of motivation to delve into the BIM methodology.

Block 2: Comprehension BIM. (Figure 1.) Evaluating the various answers in terms of understanding the acronym ‘BIM’, the words methodology, method or system, software set and interdisciplinary stand out by repetition. Regarding this point, a series of questions on BIM comprehension are also asked, where the answers range from 1 to 5, where 1 is ‘disagree’ and 5 is ‘agree’.

- 58.3% say they completely disagree with the claim that BIM is the same as Revit. The rest of the answers are disaggregated to a much lesser extent among the other options.
- 87.5% say they agree, rating between 4 and 5, with the statement ‘BIM improves my understanding of buildings’ and 70.8% say they completely agree with their desire to use BIM more often. They also state, 83.3% and, valuing between 4 and 5, that the results obtained with BIM are greater than those obtained in the traditional way.
- 91.7% of respondents say they see BIM as an opportunity and not as a threat.

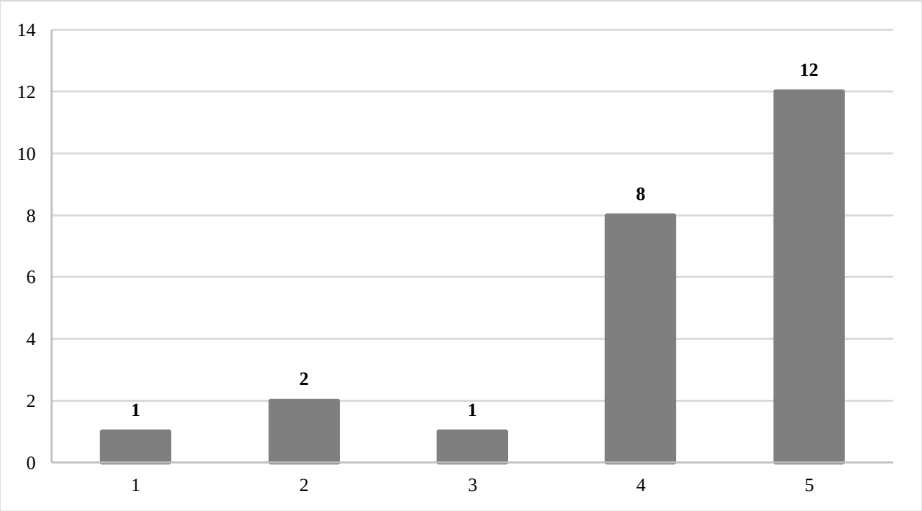

Fig. 1. The table shows the students response to the affirmation: The results are higher than those obtained in a traditional way. On a rate scale where 5 is 'agree' and 1 is 'disagree'.

Block 3: Knowledge Acquired. (Figure 2). Regarding the knowledge acquired, the answers remain clear, but stand out somewhat less than the previous observations due to the greater dispersion of the results. In an assessment from 1 to 5, where 1 is 'low' and 5 'high', the participants are asked the level of knowledge acquired in the workshop regarding the contents taught: 1) introduction and modeling, 2) advanced modeling and presentation, 3) tables and management, 4) collaboration and sustainability. They were also asked about their knowledge and skills in Revit and BIM.

- 75% of students respond in a grade between 3 and 4 in terms of introduction and modeling. Slightly less, 70.9% respond in a grade between 3 and 4 to advanced modeling and presentation. And in terms of collaboration and sustainability, 66.7% also respond to a grade between 3 and 4. They acknowledge having acquired less knowledge and in a more differentiated way than those mentioned above, in tables and management, since 70.8% respond to a grade between 2 and 3.
- In terms of knowledge and skills, none of the respondents considered having high knowledge and skills in both Revit and BIM. In both questions, approximately 70% of those surveyed consider that they have a medium or medium-high level. However, in the case of Revit, most of the respondents consider it to be medium-high and in the case of BIM, the majority are in the medium level.

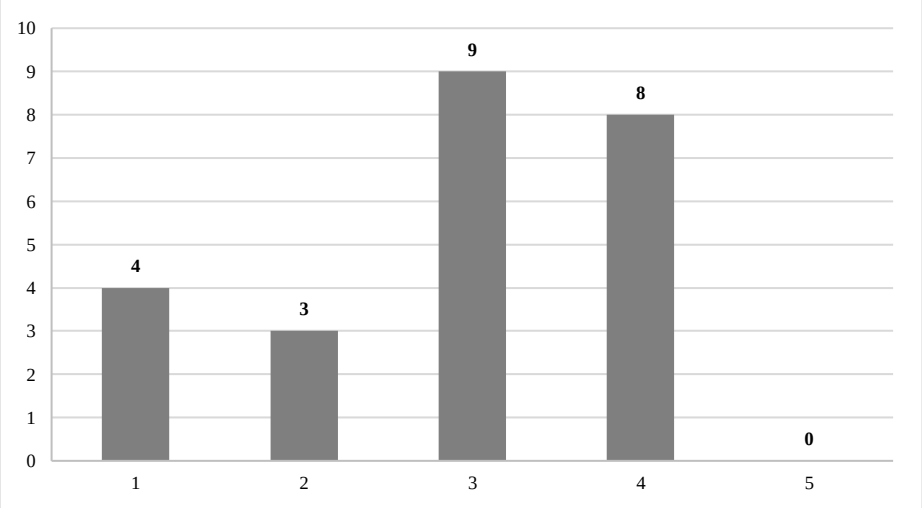

Fig. 1. The table shows the students response to the question: How would you define your knowledge and skills in BIM? On a rate scale where 5 is 'high' and 1 is 'low'.

Block 4: Development and use of BIM. (Figure 3). Most respondents say that BIM can be a useful tool in their learning and that it can lead to an improvement in project development. 95.8% would like BIM to be included in their college curriculum.

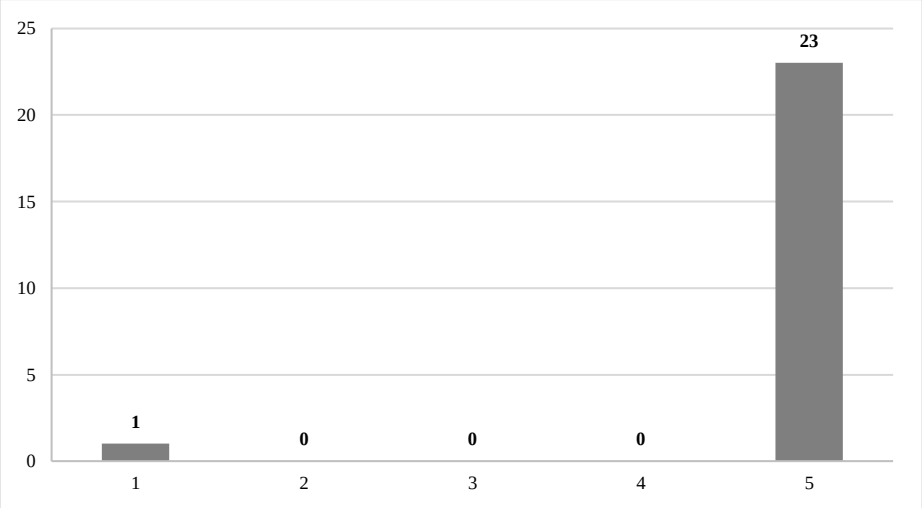

Fig. 2. The table shows the students response to the question: Would you like BIM to be included in your CV? On a rate scale where 5 is 'agree' and 1 is 'disagree'.

Teaching observations. According to the teachers in front of the group Georgina Sandoval and Fernando Minaya Hernandez, the students enjoyed a project that was deeply involved with real scenarios. Previous work outside the classroom made them aware of the problems of the community. With their selfless and active participation, their civic commitment was observed. As for the required deliverables, these were of satisfactory quality, considering that most students had little or no prior knowledge of BIM and Revit, and that the duration of the workshop was very short.

4 Discussion

A workshop based on new technologies shows a greater involvement of young students, in particular the male gender. From the positive assessment of the explanatory method of the workshop, together with the fact that most of the participants found Revit an user friendly software, it can be said that the knowledge and understanding of it, motivated the students to learn more the BIM methodologies.

The concepts that participants repeatedly mention about the definition of BIM are correct, so it can be deduced that they have understood its operation and basic concepts. However, 41.7% say they see Revit and BIM as synonymous, confusing software with methodology. This may be due to the short duration of the workshop. This fact is deducible from the results in which they consider to have a lower level in BIM than in Revit, being the section of tables and information management where they say to have acquired less knowledge. Even with the least voted section, the results are clearly very positive in terms of the level of knowledge acquired in the workshop.

Participants state that BIM improves the understanding of the architectural project and that the results are greater than those obtained in the traditional way. It is not surprising, since a virtual model improves the visualization and therefore improves the conception of the architectural project. It also helps with other aspects of the construction process, as it adds all kinds of necessary information. We must not forget the complexity that this entails, as mentioned by the participants, the process is complicated exponentially. The transition from pencil to CAD was a change of tool and the transition from CAD to BIM systems is a methodological change (Besné, Fonseca & Navarro, 2020). As the figures show conclusively, the current generation of students claims to see the BIM methodology as an opportunity. In addition, they want to use it more often, because as mentioned, it is useful in their learning and represents an improvement in the development of their projects. The results show great interest in the change, corroborated by the most significant data that shows that 95.8% of respondents want BIM to be included in the curriculum.

Being the first coordinated workshop between the universities UPC, UAM and La Salle, there are some obvious limitations with its evaluation due to the lack of historical-statistical data, especially because students from different and geographically distant schools were involved in solving a project with a real context in the application of BIM. Therefore, it is hoped to continue collaborating between academic institutions in building a project-based BIM learning framework in order to obtain more conclusive results in this type of practice.

5 Conclusions

The 1st International BIM Workshop was conducted as a case study to investigate BIM training, especially students' perceptions and motivations. The main perception on the use of the methodology is that it was an enriching experience. The main results observed were: increased motivation, development of technological skills, communicative and modeling skills, social commitment and collaboration. But the interest of teachers in assessing the need for such methodologies is not enough for their integration into academic curricula, extensive research needs to be conducted. It is opportune at this point, to clarify that the Workshop was carried out in an extracurricular way and, as shown by the most outstanding figure of the research, the students appreciate that in the future the methodology will be included in the curriculum. The workshop was proposed as a training complement and one of the objectives will be to evaluate in a future publication the impact it has had on the motivation and learning of the students.

To promote BIM and its advantages, it is also necessary to consider related technologies for proper understanding building and management as a whole. These technologies are augmented reality (AR), cloud computing, Big Data, Internet of Things (IoT), use of sensors on site (3D scanner), etc. The agents involved in the building process are increasingly a multi-tool profile, however, they receive virtually the same training as with traditional systems. Which leads, not only to integrate BIM in the academic curriculum, but also, to rethink the complete teaching guides to

evaluate their impact throughout the academic course and in a transversal way in different subjects.

There have been few professional BIM implementation studies for some years, but there is still a lot of uncertainty about academic results. This study aims to serve as a reference point to continue strengthening the connection between BIM training and the demands of the professional sector. BIM allows teachers to show how the components of a building are related, a fact that is both practical and didactic. As this research and many others demonstrate, not imparting these teachings today or in the near future in academia leads to the obsolescence of a potentially motivated and prepared generation in the use of these methodologies. Finally, the PBL provided the basic guidelines for improving BIM educational instruction and allowed students to actively participate in their learning process, cooperating with other students and instances, reflecting, making decisions, and creating joint knowledge. It was also an effective method to motivate them and involve them in real problems.

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References

1. Bernal, A. y Rodríguez, Á. (2018, mayo). Plan Estratégico de Expresión Gráfica para implementar BIM en un Grado en Arquitectura Técnica. En la Cuarta Conferencia Internacional sobre Avances en la Educación Superior.
2. Besné, A., Fonseca, D., & Navarro, I. (2020, June). Why Building Information Modelling and why now: Literacy study of BIM implementation in architecture. In 2020 15th Iberian Conference on Information Systems and Technologies (CISTI) (pp. 1-6). IEEE.
3. Ferrandiz, J., Banawi, A., & Peña, E. (2018). Evaluating the benefits of introducing “BIM” based on Revit in construction courses, without changing the course schedule. Universal Access in the Information Society, 17(3), 491-501.
4. Ferrandiz, J., Fonseca, D., & Banawi, A. (2016, July). Mixed method assessment for BIM implementation in the AEC curriculum. In International Conference on Learning and Collaboration Technologies (pp. 213-222). Springer, Cham.
5. Fonseca, D., Sánchez-Sepúlveda, M., Besné, A., Redondo, E., Zapata, H., Navarro, I., Pla, J., Sánchez, J. and Solà, C. (2020). Combining BIM systems and Video-Games engines in Educational Ephemeral Urban and Architectural Proposals. In F. J. García-Peñalvo (Eds.), Proceedings of the 8th International Conference on Technological Ecosystems for Enhancing Multiculturality (TEEM 2020) (Salamanca, Spain, October 21-23, 2020)
6. Fonseca, D., Villagrasa, S., Navarro, I., Redondo, E., Valls, F., Llorca, J., ... & Calvo, X. (2017, October). Student motivation assessment using and learning virtual and gamified urban environments. In *Proceedings of the 5th International Conference on Technological Ecosystems for Enhancing Multiculturality* (pp. 1-7).

7. Jin, R., Zou, P. X., Li, B., Piroozfar, P., & Painting, N. (2019). Comparisons of students' perceptions on BIM practice among Australia, China and UK. *Engineering*, Construction and Architectural Management.
8. León Cascante, Í., & Pérez Martínez, J. J. (2018). Docencia colaborativa en BIM. Desde la tradición y dirigida por la expresión gráfica arquitectónica. EGA. Revista de Expresión Gráfica Arquitectónica, 23(32), 76-87.
9. Marcos Alba, C. L. (2017). BIM Implications in the Design Process and Project-Based Learning: Comprehensive Integration of BIM in Architecture.
10. Navarro, I., Redondo, E., Sánchez, A., Fonseca, D., Martí, N., & Simón, D. (2012, June). Teaching evaluation using augmented reality in architecture: Methodological proposal. In *7th Iberian Conference on Information Systems and Technologies (CISTI 2012). IEEE.*
11. Sánchez, A., Redondo, E., Fonseca, D., Navarro, I. (2014). Evaluación del desempeño académico mediante realidad aumentada en la carrera de ingeniería. A: *Conferencia anual sobre fronteras en la educación. "2014 IEEE Frontiers in Education Conference Proceedings"*. Madrid: Instituto de Ingenieros Eléctricos y Electrónicos (IEEE), 2014, p. 1527-1533.
12. Sandoval, M. Á. P., Delgado, I. N., & Sandoval, G. (2020, April). Building Information Modeling Academic Assessment. In World Conference on Information Systems and Technologies (pp. 231-237). Springer, Cham.
13. Shafiq, M. T., Matthews, J., & Lockley, S. (2013). A study of BIM collaboration requirements and available features in existing model collaboration systems. *Journal of Information Technology in Construction (ITcon), 18*, 148-161.
14. Shults, R. (2019). Development and implementation of innovative educational modules on architectural photogrammetry for bachelor's degree curricula in architecture. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*.
15. Suwal, S., & Singh, V. (2018). Assessing students' sentiments towards the use of a Building Information Modelling (BIM) learning platform in a construction project management course. European Journal of Engineering Education, 43(4), 492-506.
16. Tsai, M. H., Chen, K. L., & Chang, Y. L. (2019). Development of a project-based online course for BIM learning. Sustainability, 11(20), 5772.
17. Zhang, J., Xie, H. y Li, H. (2018). Aprendizaje basado en proyectos con planificación de implementación para la participación de los estudiantes en las clases BIM. En t. J. Eng. Educ, 35, 310-322.