

SUPPORT TOOL FOR ENGINEERING EDUCATION THROUGH BIM LEARNING OBJECTS

ABSTRACT

Engineering education represents a great challenge for professors, considering the large amount and complexity of involved content in the area, as well as the need to develop different students' competencies and skills. In the process, it is common that learning difficulties arise, which must be identified and worked on to make learning more effective. As a facilitating agent, the use of Information Technology resources, such as Building Information Modeling (BIM) can offer learning benefits. Therefore, the present work aimed at developing, through the Design Science Research method, a teaching-learning engineering content planning tool through BIM learning objects. The method consisted of three basic steps: (1) Problem Awareness; (2) Suggestion, to propose the teaching-learning engineering content planning tool (artifact); and (3) Development, to develop BIM learning objects aimed at identified difficulties. As contributions, a tool that can be applied by professors of engineering disciplines related to BIM was obtained, becoming an alternative to facilitate content learning and competencies development.

Keywords: BIM; education; learning objects; construction management.

1 INTRODUCTION

According to Mattana (2017), Construction Management integrates multiple activities, such as budgeting, purchasing, people management, communication, and planning, involving diverse and inter-related contents linked to design, construction systems, and Economic Engineering. These contents require the development of technical, communication, and leadership competencies (ABMES, 2019), as well as high cognitive levels from students (BLOOM, 1983). Given this complexity, the research questions how learning in Construction Management can be made more effective. Information Technology resources, particularly BIM, can support the solution of complex problems (DOSSICK; NEFF, 2011), offering benefits to construction learning by adding value to the educational process (WU; ISSA, 2013). Thus, this research highlights the relevance of a BIM-supported teaching-learning planning tool to improve Engineering education and foster the development of essential competencies and skills.

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2 THEORETICAL FRAMEWORK

The chapter on the theoretical framework will cover the development of competencies and skills in students, both to the National Curriculum Guidelines, focused on subjects of great relevance for the operation of undergraduate Engineering courses. In addition to the DCN competencies, there are also BIM competencies and uses, which can be used in educational programs. Such competencies represent a skill, an activity, or a result that can be evaluated, learned, or applied (BIM EXCELLENCE INITIATIVE, 2020). The information that will be presented in the following topics is organized into tables to facilitate understanding of each topic. Such tables can be found in a file available through the following link: <https://www.dropbox.com/scl/fi/dx7g24kafy9rqaw4y7bqt/Tabelas.xlsm?dl=0&rlkey=5i-757z2b1a85pz9a5pn64nets>

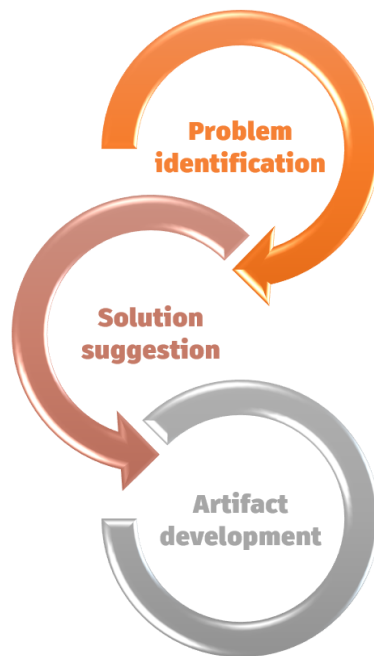
3 RESEARCH METHOD

Regarding the research type, this study is classified as qualitative, as it seeks to develop a theoretical model based on individual experiences (CRESWELL, 2007; RICHARDSON, 2011). Through particular experiences, the research aims to create a teaching-learning planning tool that functions as a standard model and promotes the integration of BIM into Engineering education as a whole. The qualitative

approach is appropriate given the study's focus on understanding processes and generating a structured artifact rather than producing statistical generalizations.

In terms of research strategy, Design Science Research (DSR) was adopted, since the study involves the researcher's immersion in a real context to identify problems and creatively propose solutions to practical needs. According to Vaishnavi and Kuechler (2007), DSR follows stages such as problem awareness, suggestion, and development, which guided the methodological structure of this research (Figure 1).

► Figure 1: Methodology

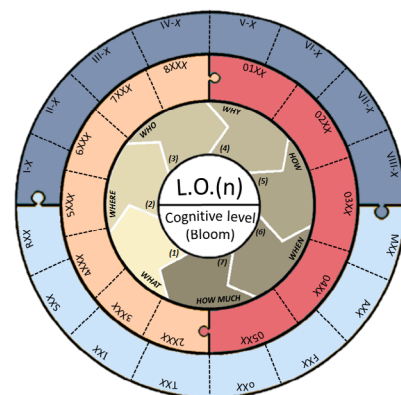


Source: Authors (2025)

The developed content is organized through a diagram called the “learning compass,” designed to guide users in unders-

tanding the relationships among BIM learning objects, competencies and skills, BIM uses, template, and Bloom's Taxonomy cognitive levels (Figure 2).

► Figure 2: Delimited learning compass for inserting codes



Source: Authors (2025)

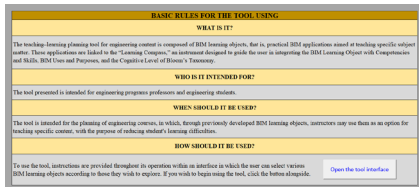
To populate the compass, reference tables discussed in the literature review were consulted. Due to the diversity of content, BIM uses and competencies were divided into subsections identified by specific codes. BIM uses are represented according to the CIC-PSU and BIME Initiative classifications, while competencies and skills follow BIM competencies and DCN guidelines. The template structure is based on the 5W2H method, and the cognitive level achieved by each BIM learning object is positioned at the center of the learning compass.

4 RESULTS

An MS Excel spreadsheet was adopted to present the developed BIM learning objects and the learning compass, which integrates templates, BIM uses, compe-

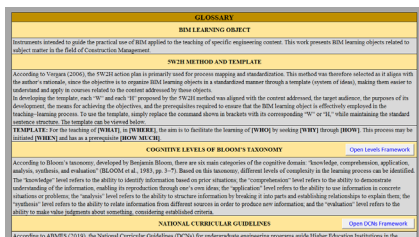
tencies and skills, and the cognitive levels of Bloom's taxonomy. Initially, users are provided with instructions for using the tool (Figure 3), as well as a glossary of key terms to ensure proper understanding before interacting with the spreadsheet (Figure 4).

► Figure 3: Software interface



Source: Authors (2025)

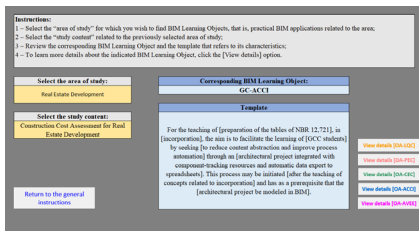
► Figure 4: Glossary



Source: Authors (2025)

After becoming familiar with the instructions, users select the area and content they wish to study and are then presented with the corresponding BIM learning objects through an interactive interface (Figure 5).

► Figure 5: Interactive screen with details



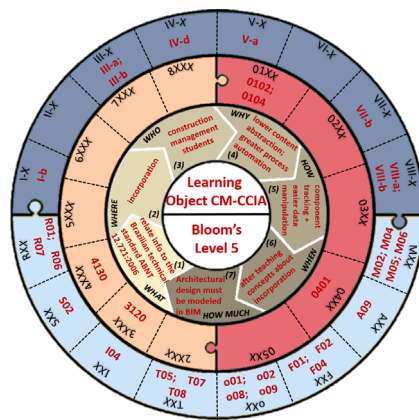
Source: Authors (2025)

Once a learning object is selected, its information is displayed via a template, allowing users to assess whether it meets

their learning needs. If suitable, users can access additional information by selecting the “see details” option, which redirects them to a new spreadsheet containing the full characteristics of the chosen learning object. If not, users may restart the search process to identify a more appropriate option.

When the detailed view is accessed, the learning compass is displayed, linking the BIM learning object to specific competencies and skills, BIM uses, the template structure, and the corresponding cognitive level of Bloom's taxonomy. To support the interpretation of the compass, which uses coded references for competencies and BIM uses, users are advised to consult the tables available at the electronic address provided in the theoretical framework chapter (Figure 6).

► Figure 6: Learning object classification

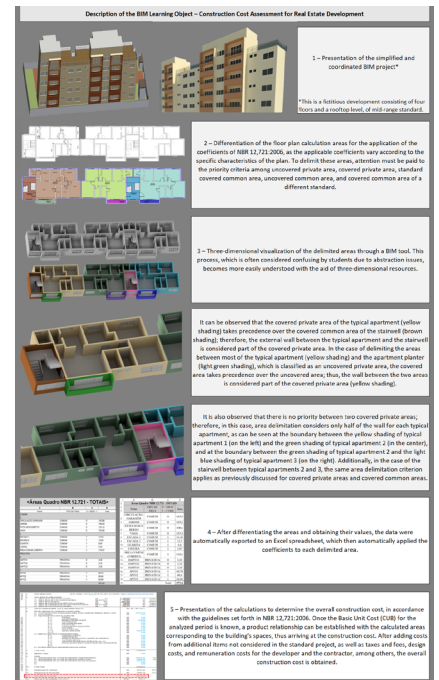


Source: Authors (2025)

Additionally, the spreadsheet presents detailed descriptions of each BIM learning object, including step-by-step guidance for its application, as

shown in Figure 7. The focus is not on identifying specific BIM software tools or commands, but rather on explaining the overall process, allowing users to select the tools with which they are most familiar. This approach provides flexibility and accommodates different user preferences.

► Figure 7: Learning object details



Source: Authors (2025)

The complete interactive spreadsheet containing all BIM learning object details is available through the provided access link: <https://drive.google.com/file/d/19jd3wGMAwD-GLIT3B6OzMZySVIchPSl9/view?usp=sharing>

5 FINAL CONSIDERATIONS

The literature highlights BIM's potential as a pedagogical tool capable of supporting students in understanding the com-

plexity of construction projects. Although BIM is widely applied in areas such as three-dimensional modeling, its use remains limited in more specific fields, including Construction Management. In this context, the present study achieved its objective by developing a planning tool to support the teaching and learning of Engineering content through BIM, focusing specifically on Construction Management. The developed artifact shows potential to enhance student learning; however, it is still premature to draw definitive conclusions about its benefits due to the limited number of applications. The learning compass stands out as a contribution by mapping BIM uses alongside the development of essential competencies and skills for student training. Additionally, the organization of BIM learning objects through a standardized template supports the systematization and structuring of BIM applications for diverse educational contents. Despite its contributions, the study is limited by the absence of an evaluation of the BIM learning objects' effectiveness in reducing learning difficulties and by its application being restricted to a single area, reinforcing the need for further development and expansion.

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