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Adoption of BIM Software in the Architecture Course of Civil Engineering Program

Adoção de softwares BIM na disciplina de Arquitetura em curso de Engenharia Civil

Adopción del software BIM en la disciplina Arquitectura en una carrera de Ingeniería Civil

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RESUMO
O Building Information Modeling (BIM) é reconhecido como uma abordagem sustentável para o desenvolvimento de projetos de arquitetura e engenharia, operando em todas as fases do ciclo de vida de uma edificação. Apesar da importância, a adoção do BIM no ensino tem sido gradual. O objetivo do artigo é investigar a adesão dos estudantes do curso de engenharia civil da Escola Politécnica da Universidade de Pernambuco (POLI/UPE) ao uso de softwares BIM na disciplina de arquitetura, ministrada no 6º período do curso. O estudo longitudinal abrangeu dados quantitativos de 2020 a 2023, visando classificar os projetos entregues conforme o software utilizado (2D ou BIM), identificar tendências temporais no uso de softwares BIM e elaborar hipóteses para compreender os motivos da escolha do software. Observou-se que o uso de softwares 2D era predominante entre os estudantes em 2020, com 63,95% de uso, porém houve um aumento gradual na adoção de softwares BIM ao longo do tempo, tornando-se expressivo em 2023, com 80,85% de uso. Este estudo contribui para o entendimento das dinâmicas relacionadas à integração do BIM na formação acadêmica em Engenharia Civil, destacando o papel da universidade como promotora de práticas sustentáveis na indústria da construção, evidenciando a importância do BIM como ferramenta para a eficiência e qualidade ao longo do ciclo de vida das edificações.

PALAVRAS-CHAVE: Modelagem da informação da construção. Ensino. Tecnologia.

SUMMARY
Building Information Modeling (BIM) is recognized as a sustainable approach to the development of architecture and engineering projects, operating at all phases of a building's life cycle. Despite its importance, the adoption of BIM in education has been gradual. The aim of this article is to investigate the adoption of BIM software by civil engineering students at the Polytechnic School of the University of Pernambuco (POLI/UPE) in the architecture course, taught in the 6th semester. The longitudinal study encompassed quantitative data from 2020 to 2023, aiming to classify the delivered projects according to the software used (2D or BIM), identify temporal trends in the use of BIM software, and develop hypotheses to understand the reasons for the software choice. It was observed that the use of 2D software was predominant among students in 2020, with 63.95% usage, but there was a gradual increase in the adoption of BIM software over time, becoming significant in 2023, with 80.85% usage. This study contributes to the understanding of the dynamics related to the integration of BIM in academic training in Civil Engineering, highlighting the role of the university as a promoter of sustainable practices in the construction industry, emphasizing the importance of BIM as a tool for efficiency and quality throughout the building life cycle.

KEYWORDS: Building Information Modeling. Education. Technology.

RESUMEN
El Modelado de Información de Construcción (BIM) es reconocido como un enfoque sostenible para el desarrollo de proyectos de arquitectura e ingeniería, operando en todas las fases del ciclo de vida de un edificio. A pesar de su importancia, la adopción del BIM en la educación ha sido gradual. El objetivo de este artículo es investigar la adopción de software BIM por parte de los estudiantes de ingeniería civil de la Escuela Politécnica de la Universidad de Pernambuco (POLI/UPE) en la asignatura de arquitectura, impartida en el 6º semestre. El estudio longitudinal abarcó datos cuantitativos de 2020 a 2023, con el objetivo de clasificar los proyectos entregados según el software utilizado (2D o BIM), identificar tendencias temporales en el uso de software BIM y elaborar hipótesis para comprender los motivos de la elección del software. Se observó que el uso de software 2D era predominante entre los estudiantes en 2020, con un 63.95% de uso, pero hubo un aumento gradual en la adopción de software BIM con el tiempo, volviéndose significativo en 2023, con un 80.85% de uso. Este estudio contribuye a la comprensión de las dinámicas relacionadas con la integración del BIM en la formación académica en Ingeniería Civil, destacando el papel de la universidad como promotora de prácticas sostenibles en la industria de la construcción, enfatizando la importancia del BIM como herramienta para la eficiencia y calidad a lo largo del ciclo de vida de los edificios.

PALABRAS CLAVE: Modelado de Información de Construcción. Educación. Tecnología.

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1 INTRODUCTION

Sustainable Development Goal (SDG) 9, promoted by the United Nations, aims to build resilient infrastructure, promote inclusive and sustainable industrialization, and foster innovation. Its goals include developing quality and accessible infrastructure, promoting sustainable and inclusive industrialization, and strengthening scientific and technological research (UN, 2024).

In this context, Building Information Modeling (BIM) consists of a set of technologies and organizational strategies that foster cooperation among various entities and areas of expertise in the construction industry (Miettinen; Paavola, 2014; Rodrigues; Vasconcelos, 2024). These technologies and strategies aim to enhance performance and quality throughout all stages of a building's life cycle, from planning to construction and maintenance (Van Tam *et al*., 2023; Ahmed *et al*., 2018; Arayici *et al*., 2011).

The use of BIM by construction management companies has often been limited by adherence to traditional processes due to various implementation barriers (Arayici *et al*., 2012; Georgiadou, 2019). However, many owners have already recognized its potential (Ghaffarianhoseini *et al*., 2017; Hardin; Mccool, 2015).

There is an ongoing debate about whether BIM represents an evolution of Computer-Aided Design (CAD) or a complete transformation in the construction industry (Azevedo; Morais; Lira, 2020; Borkowski, 2023; Akbiyik *et al*., 2023). These authors highlight significant events that have shaped BIM's trajectory, from its conception to its implementation in the construction industry.

Despite the challenges the construction industry faces in adopting BIM (Sepasgozar *et al*., 2023), it has proven essential for the sector's evolution. Integrating BIM into civil construction not only optimizes processes but also elevates standards of quality, efficiency, precision, and collaboration in the design and execution of engineering projects (Azevedo *et al*., 2024; Azevedo *et al*., 2023; Chen; Luo, 2014; Ghaffarianhoseini *et al*., 2017; Miettinen; Paavola, 2014).

However, the transition to full BIM adoption should not be limited to the workplace. Besné *et al*. (2021), Nushi *et al*. (2017), and Yusuf *et al*. (2017) emphasize the increasing demand for BIM integration in the productive and educational processes of educational institutions, due to the requirements and recommendations of international governmental institutions. These authors reveal a consensus on the need to develop common academic guidelines for universities to define strategies for curriculum modifications and teaching and learning methods. Safour *et al*. (2023) agree and stress the importance of publishing academic studies on BIM and the proper adoption of the BIM culture within universities. Implementing BIM in higher education requires strategies to overcome challenges such as curricular rigidity, departmental immobility, and lack of interdisciplinary collaboration (Abdirad; Dossick, 2016; Babatunde; Ekundayo, 2019; González *et al*., 2019).

Barison *et al*. (2010) highlight expectations regarding BIM in terms of performance changes for architects and engineers, also asserting the importance of BIM knowledge in academic studies and emphasizing how this content is being incorporated into architecture,

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engineering, and construction (AEC) courses in universities worldwide. Supporting the authors Abdirad and Dossick (2016), they note that in recent years, BIM adoption has increased in the AEC sector, and in response to this growth, industry and academia have realized that BIM education in university curricula is an important requirement to meet the industry's educational demands.

Adopting methodological strategies to improve BIM education is crucial for achieving good results, potentially bringing motivation and understanding through visualization and enhancing communication and collaboration among students (Azevedo *et al*., 2024; Besné *et al*., 2021). In this methodological context, it is essential to investigate the adherence of AEC students to using BIM software, as clarified by Besné *et al*. (2021). Therefore, the purpose of this article is to investigate the adherence of civil engineering students at the School of Polytechnic of the University of Pernambuco (POLI/UPE) to the use of BIM software in the Architecture course taught in the 6th semester.

2 CHARACTERIZATION OF THE ARCHITECTURE COURSE

The architecture course is mandatory and offered at the School of Polytechnic of the University of Pernambuco for students in the sixth semester of the civil engineering undergraduate program. With a workload of 60 hours, its content covers the study of architectural and urban production from Eastern Antiquity to the 21st century. It also explores the conditioning aspects of the project, such as legal, physical, environmental, functional, economic, aesthetic, cultural, and technical factors.

The objective of the course is to provide students with a comprehensive view of architecture and project activity, considering the legal, functional, and environmental comfort conditioning, with an emphasis on the architectural project in the city of Recife.

The content of the course is divided into two units. In the first unit, students receive expository content to support the development of feasibility studies and architectural drafts. In the second unit, they develop the architectural project on a chosen site in the city of Recife. Students have the freedom to choose the software for project development; however, throughout the program, they have only been exposed to CAD software during the graphic representation course in the third semester.

3 METHODOLOGY

This study is characterized as exploratory research since it aims to investigate students' adherence to using BIM software in the Architecture course, constituting an initial characterization of the problem (Nooy; Mrvar; Batagelj, 2005). It is longitudinal in nature, involving data analysis over a specific period (Caruana *et al*., 2015). With a qualitative approach, it seeks to collect and analyze information quantitatively (Lunetta; Guerra, 2023).

For conducting the research, the methodological steps can be described as follows:

a. Literature review: A literature review was conducted to support the investigation.

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b. Data collection: Data collection was carried out through a review of architectural projects developed by students of the civil engineering course at POLI/UPE from 2020 to 2023. The projects were obtained from delivery records in the architecture course on the Google Classroom platform.

c. Project classification: The projects were classified based on the software used for developing the architectural draft for multifamily buildings. The software was divided into two categories: those developed in 2D or BIM. Each project was analyzed to determine which software category was used in its preparation.

d. Formulating hypotheses regarding the reasons behind students' software choice: Based on the collected data and literature, hypotheses were formulated to understand why students chose to use specific software.

4 RESULTS AND DISCUSSION

4.1 Data Analysis

During the analysis of the data collected between the years 2020 and 2023, a total of 294 students who developed architectural projects for the architecture course was obtained. When evaluating the submission of the projects, a significant change in the pattern of software usage in the course was observed, as indicated in Figure 1. Initially, in 2020, there was a preference for CAD software, with 63.95% of projects developed using this technology compared to the use of BIM software. However, over the following years, this preference gradually shifted, with an increasing adoption of BIM software. Specifically, in 2021, the usage of both types of software was balanced, but by 2023, Revit became predominant in project development, with a share of 80.85%. This trend suggests a notable increase in students' intention to adopt BIM tools as the primary means for developing architectural projects. It is worth noting that in 2023, the instructors of the course encouraged the use of BIM by offering extra points to students who chose to learn and develop their projects using this technology. This strategy may have influenced the growing adoption of BIM during this period.

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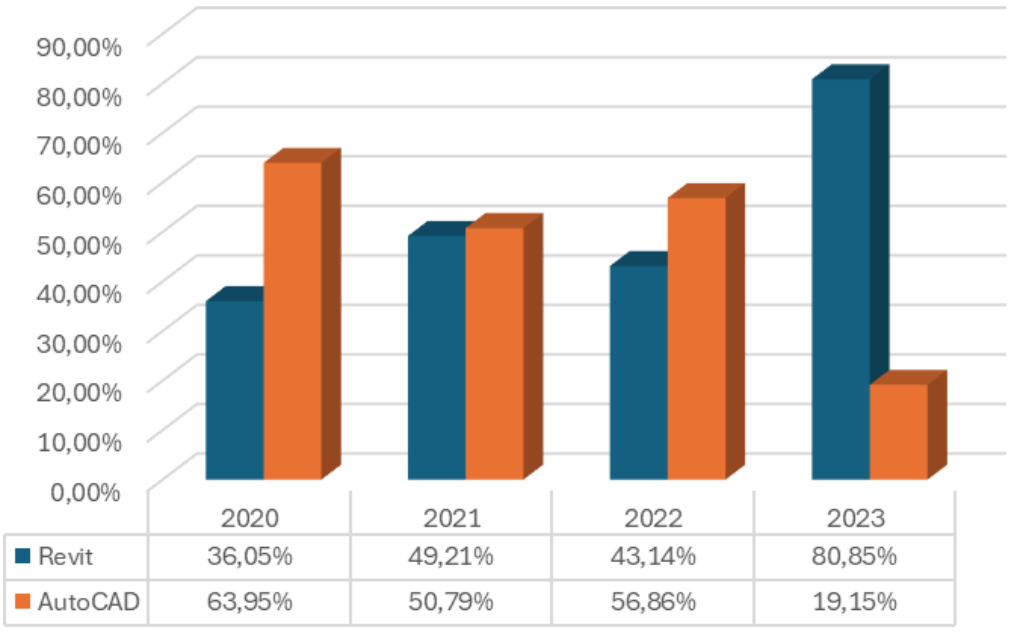
Figure 1 – Software usage in the architecture course



	2020	2021	2022	2023
Revit	36,05%	49,21%	43,14%	80,85%
AutoCAD	63,95%	50,79%	56,86%	19,15%

Source: Authors

By examining the total number of projects submitted during the study period, it was found that 75 projects were delivered using 2D software and 87 with BIM software. Among them, the projects were developed either individually or in pairs. Although the course allows for both individual and pair project development, a predominant trend of pair work was observed. For projects developed using CAD software, 16 were completed individually and 56 in pairs, while among the projects developed using BIM software, 14 were done individually and 73 in pairs.

Figure 2 presents a tree map illustrating the relationship between projects developed individually and in pairs. The development of projects using BIM software in pairs is somewhat more pronounced compared to CAD software. This preference can be interpreted as a strategy by students to tackle the challenge of learning a new software, demonstrating a collaborative approach to overcoming individual learning barriers.

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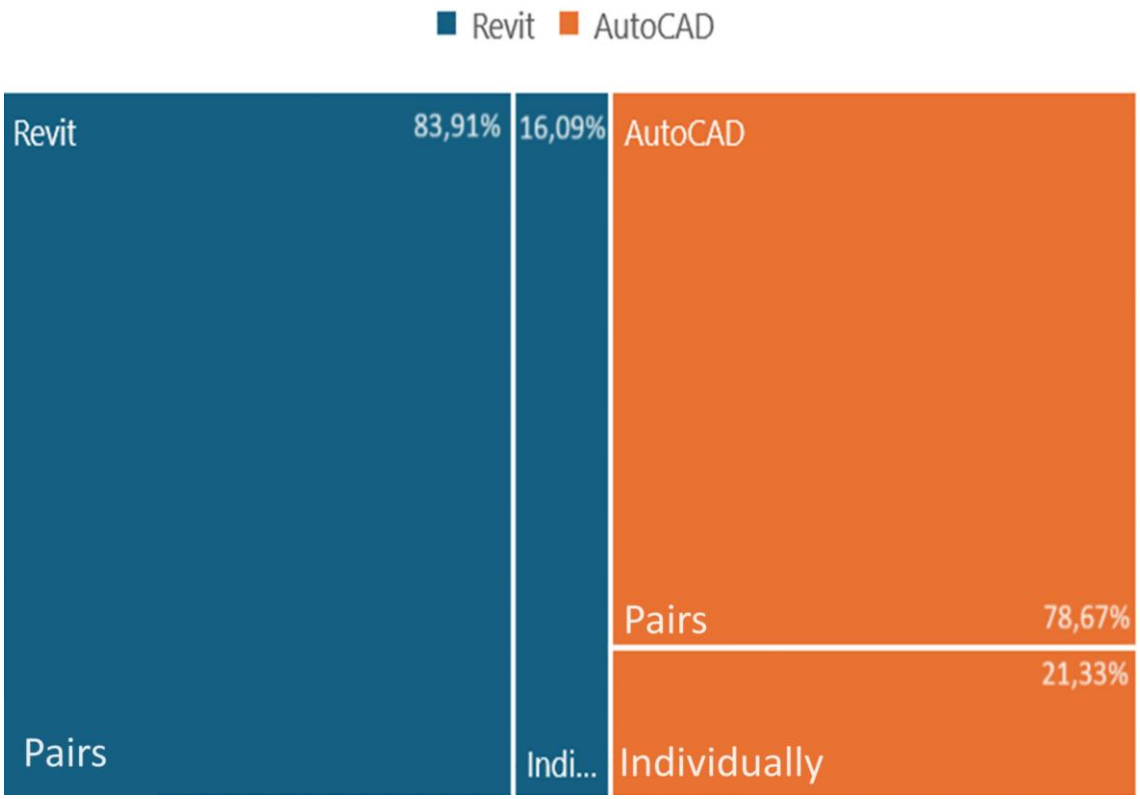
Figure 2 – Tree map of the relationshop between projects developed individually and in pairs.



Source: Authors

4.2 Hypotheses

Although the total number of projects submitted using BIM has surpassed those developed with CAD, there remains a considerable proportion of projects delivered in CAD. This suggests that, despite the growing adoption of BIM, some students still opt for CAD. One possible explanation for this choice may lie in the students' prior familiarity with CAD, given that they did not have exposure to BIM tools during their undergraduate studies. The lack of institutional policies or curricular changes that explicitly promote the use of BIM may have contributed to this ongoing preference for CAD among some students.

Additionally, the literature suggests that BIM is increasingly in demand in the job market, offering advanced resources for three-dimensional modeling, performance analysis, and real-time collaboration (Azevedo; Vasconcelos, 2024; Chathuranga *et al*. 2023; Ershadi *et al*., 2021; Wagiri *et al*., 2023), which allows for the development of projects more quickly, reliably, and accurately (Abdulwahhab; Naimi; Abdullah, 2022; Auman; Alwan; Mcintyre, 2020). Furthermore, the integration of all information into a single model reduces the need for rework and enhances the consistency and accuracy of the project (Rui; Yaik-Wah; Siang, 2021; Samimpay; Saghatforoush, 2020). This may have influenced the increasing rate of BIM usage in the architecture course, even considering the students' familiarity with CAD during their studies. Moreover, institutional and faculty encouragement plays a crucial role in stimulating the use of BIM in academia (Barros; Brígitte, 2021; Lima *et al*., 2020). Based on the data and literature

analysis, the following hypotheses can be formulated to understand the reasons behind the choice of a particular software:

- Familiarity with the software: Students may have opted for CAD software due to their prior familiarity with this technology. Since they were exposed to CAD in the Graphic Expression II course during the third semester, they may have felt more comfortable and confident using this tool. Likewise, students who have gained familiarity with BIM software outside of the university, such as in courses or internships, may have chosen to use it for project development.
- Job market demands: The growing demand for professionals skilled in BIM may have influenced students' choices regarding this technology. As BIM is increasingly sought after in the construction industry, students may have opted to acquire BIM skills to enhance their employability after graduation.
- Faculty recommendations: The encouragement from architecture faculty to use BIM software, offering extra points to students who opted for this technology in 2023, may have significantly influenced students' choices.
- BIM benefits over CAD software: Students may have chosen BIM due to their perception of its advantages in terms of efficiency and quality in architectural project development.

5 CONCLUSIONS

The gradual shift from CAD to BIM among students reflects an adaptation to market demands, where mastery of BIM is increasingly valued. However, the persistence of projects in CAD highlights the importance of teaching approaches that consider the diverse needs of students. This indicates the need for institutional policies that encourage the transition to BIM and provide adequate resources.

The use of BIM in education offers various benefits. It provides a more integrated understanding of the design process, allowing for simulations and three-dimensional visualizations. Additionally, it facilitates collaboration among students and faculty, promoting a collaborative learning environment and preparing students for the demands of the current job market.

As a limitation of the study, the absence of interviews or questionnaires to understand the reasons behind students' software choices is noted. Future research should incorporate these approaches. Furthermore, it is suggested to investigate more thoroughly the factors influencing BIM adoption and the long-term impacts of its use on students' training and careers, to inform more effective teaching strategies and institutional policies.

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