Teaching of Building Information Modeling (BIM) in Higher Education Institutions in Brazil: analysis of the Theses and Dissertations produced in the period from 2013 to 2020

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ABSTRACT

Building Information Modeling (BIM) has emerged as a necessary tool in the architecture, engineering, construction and operations scenario, offering an innovative and integrated approach not only for project development, but also contributing to the construction management and maintenance of buildings. . In the Brazilian context, academia has dedicated special attention to BIM, reflected in the production of theses and dissertations carried out over the last few years. This research aimed to identify the main trends and pedagogical approaches used in the productions found, presenting their strengths and advances verified in the use of this methodology, as well as the weaknesses or limiting points, based on Brazilian academic production on teaching BIM in the period from 2013 to 2020, resulting from the analysis of theses and dissertations published in the CAPES Catalog of Theses and Dissertations, which address the topic of Construction Information Modeling or Building Information Modeling in the dimension of its teaching. classifies as applied, exploratory, with a qualitative approach, using the bibliographic research method and application of the content analysis technique. It is hoped that, through the results obtained, the adoption of the BIM methodology in undergraduate courses in architecture and urbanism and related areas can be encouraged in the country.

KEYWORDS: BIM. Building Information Modeling. Teaching.

1 INTRODUCTION

Building Information Modeling (BIM), is represented by a set of technologies and integrated processes that treat the necessary information for a project, allowing its creation in 3D modeling, as well as its use and update collaboratively at any stage of its life cycle.

According to Succar (2010), the conceptual dimension associated with BIM tools promotes revolutionary changes in all organizational scales simultaneously, enabling organizations and design teams from the Architecture sectors, Engineering, Construction and Operations work collaboratively from the beginning of the project design to the maintenance management phase of the building.

This form of work provides construction professionals, architects and engineers with information and tools for the planning, design, construction and management of works, presenting as main benefits of this process, the optimization of work and interoperability between the various components necessary to develop a project, allowing to interfere in the characteristics that involve its architecture, structures, electrical and hydraulic components, drainage and lighting, among others. Provides thus, combine technologies and processes to improve the efficiency of project management, in its execution and maintenance.

Also as characteristics of the BIM methodology, can be highlighted the information generated for decision making, construction documents, performance forecast, cost estimate and planning, prior to the execution of the work, allowing the necessary adjustments, when necessary still in the design phase.

The Federal Government has progressively introduced, from January 2021 in Brazil, the use of BIM in public works. This measure brought to professionals working in the area of architecture and engineering projects the need to seek qualification due to the obligation provided for in Federal Decree 10.306 published on April 2, 2020, that establishes the use of Building Information Modelling in the direct or indirect execution of engineering works and services performed by federal public administration bodies and entities within the framework of the National Strategy for the Dissemination of Building Information Modelling (BIM BR Strategy), established by Decree no 9.983 of 22 August 2019. Therefore, independent professionals or companies working in the area of architecture and engineering projects

interested in participating in public tenders should be suitable for the use of this methodology.

Also with regard to the legal framework, projects must comply with laws, decrees, regulations, ordinances and federal, state/district and municipal rules directly or indirectly applicable to public works, and in accordance with the technical standards (TCU, 2014, p. 17).

In this sense, it is understood that the professional training to work with the compatibility of projects could be started throughout the graduation process at Higher Education Institutions (IES). The acquisition of skills, in this period, necessary for the use of BIM methodology would contribute to the improvement of technical and specialized training in meeting the various demands, especially those that seek to achieve greater effectiveness in the performance of disciplines related to the construction sectors.

With the modernization of technological models of learning in the area of architecture and urbanism, HEIs need to seek ways to adapt their curricular structures to meet the demands of students in relation to the use of methodologies and software that facilitate the development of projects, management of works and management of building maintenance.

Building Information Modeling has been used as an important tool in the construction industry, redefining processes and promoting efficiency in all phases of a project. In essence, it represents a profound transformation in the way of working of the various professionals involved in the design of architectural and engineering projects. However, for the use of this technology, it is necessary to consider the need for professional qualification and requalification.

In the Brazilian educational context, the integration of BIM in higher education arouses growing interest, reflecting the need to train professionals able to operate and innovate within this new approach and methodological proposal.

The National Curriculum Guidelines (DCN) of the undergraduate course in Architecture and Urbanism, Resolution no 2, of 17 June 2010, instituted by the Ministry of Education, National Council for Education, Chamber of Higher Education, deals in its Art. 5th of the skills and abilities in vocational training that the undergraduate course should enable and, in its paragraph XII, presents "the knowledge of computer tools (grifo nosso) for information treatment and representation applied to architecture, urbanism, landscaping and urban and regional planning" (MEC, 2023a, p. 3); and in its Article 6 it deals with the curricular contents of the course in its two knowledge centers: foundation and professional; and the course work, recommending its interpenetrability, presents in paragraph 2

> The Professional Knowledge Center will be composed of fields of knowledge intended for the characterization of the professional identity of the egress and will consist of: Theory and History of Architecture, Urbanism and Landscaping; Design of Architecture, Urbanism and Landscaping; Urban and Regional Planning; Construction Technology; Structural Systems; Environmental Comfort; Retrospective Techniques; Computer Applied to Architecture and Urbanism (emphasis added); Topography (MEC, 2023a, p. 3).

These are the two existing mentions in the current DCN of the course of architecture and urbanism published in 2010, in force in 2023, with regard to the use of information technology, under the term "informatics".

In 2023, the Brazilian Association of Architecture and Urbanism Education (ABEA) presented a proposal to change the current curriculum guidelines for the Architecture and Urbanism course, which is reported in document DCN/CNE - 13/09/2023 (MEC, 2023b), from which the following propositions are highlighted directly related to the theme treated in this research.

Article 11, when dealing with the establishment of pedagogical actions of the course in order to develop knowledge, skills, competencies and attitudes with technical, artistic and social responsibility, in its paragraph V proposes "the domain of computer tools for information processing and modeling (emphasis added) design for conception, expression, representation, experimentation and manufacturing applied to architecture, urbanism and landscape architecture" (MEC, 2023b, p. 3).

Article 14, which addresses the curricular contents organized in the two nuclei of knowledge of foundation and professional and final work of graduation, recommending its interpenetrability and possibilities to incorporate technologies and innovations that enable their use and development in the professional field, are presented in Item I. Core of Knowledge of Foundation, letter b), "Digital and Physical Modeling Processes and Tools; (emphasis added)" (MEC, 2023b, p. 5).

In its Article 36 presents the text, from which we highlight the relevant, related and possible passages for the use of BIM methodology:

> To achieve the objectives and full development of these guidelines, the Undergraduate Course in Architecture and Urbanism should be adequately equipped with specific laboratories of Environmental Comfort, Building Facilities, Mock-ups, modeling and digital manufacturing (emphasis added), Materials and construction techniques, Topography and geoprocessing, Workshops and project rooms, Facilities for research and advanced studies, Experimental sites of works and Libraries with adequate, sufficient and updated collection, including physical and digital collection, and availability of up-to-date technologies for information exchange (emphasis added)....§ 2o Access to the use of computers, media equipment, modeling and digital manufacturing (emphasis added) should be provided (MEC, 2023b, p. 13).

It is verified that, from the proposal of ABEA to change the DCN of the course of architecture and urbanism, elements that signal for the objective possibilities of incorporation of the BIM methodology in the curricular structures, inferring that the use of the term "modeling" is represents a step forward in this direction.

Although it can be verified the design evolution from the use of BIM methodology, Lucena (2020), states about the existence of educators who still disagree about the positive impact that applications can implement in the workflow of a project, because of the fear of future occur the replacement of professionals who perform this work manually, by applications in the project offices. However, there is no doubt that a software is only a computational service intended to perform actions in computer systems, and these actions are defined by professionals who have knowledge, Competence and technical ability to understand the relevant variables to be inserted in that software, to obtain the desired result in the design.

New challenges arise in the construction industry focused on four key principles: interoperability, so that data can be shared and used by different stakeholders throughout the

project life cycle; collaboration between these parties by improving communication and decision-making; innovation enabling efficiency, quality and cost reduction; and sustainability through reducing the environmental impacts of construction. In these principles, a set of other factors and variables are inserted, capable to characterize the sector of the civil construction by a complexity in which the use of BIM creates objective possibilities to assist the professionals of this area.

In this context, the present article proposes to carry out an analysis of the Brazilian theses and dissertations dedicated to BIM teaching, covering the period from 2013 to 2020, seeking to identify emerging patterns, knowledge gaps and important contributions, from a view of the state, in the period covered by this study, the teaching of BIM in Brazil. It is also emphasized that the analysis proposal aims to contribute to the continuous improvement of educational programs, promoting an integration of BIM in Brazilian educational institutions and, Therefore, strengthening the capacity of the construction sector to face contemporary challenges that arise, especially those related to sustainability aspects.

In addressing the historical evolution of BIM in Brazil, Checcucci, Pereira and Amorim (2011) report the existence of a limitation regarding the use of BIM in relation to the phases involving the operation and maintenance of a building, demonstrating the scope that this methodology can still achieve.

In the analysis of the Brazilian academic production on BIM, Checcucci (2019) concluded a qualitative research related to the theses and dissertations that were published in the period from 2013 to 2018, in the Catalog of Theses and Dissertations of CAPES on this subject, in addition to presenting the scientific production published by other researchers in previous years. Identified 8 dissertations and 4 theses, totaling 12 works distributed in 7 states of the country, on teaching and learning BIM.

The study carried out here was derived from the master's thesis held in the Graduate Program in Architecture and Urbanism, of the University Center of Várzea Grande (UNIVAG) in association with PUC Campinas - PPGAU-UNIVAG, conducted by Bonfante (2023), with the title: Possibilities for the Use of BIM Methodology in Teaching in Undergraduate Courses in Architecture and Urbanism at Higher Education Institutions of Baixada Cuiabana.

2 OBJETIVES

The general objective of this research was to identify the Brazilian theses and dissertations produced between the years 2013 and 2020, which dealt with the dimension of teaching of Building Information Modeling existing in the Catalog of Theses and Dissertations of CAPES. With the specific objective of identifying and presenting the main trends and pedagogical approaches used in the productions found, highlighting the strengths or advances in the use of this methodology, as well as the main weaknesses or limitations.

This study is justified by presenting an educational panorama in higher education related to the teaching of BIM, presented in academic productions contributing to the sustainable development of the construction sector in Brazil. Thus, it will contribute to the

Sustainable Development Goals (SDGs), more directly with SDG 11. Sustainable cities and communities - Making inclusive, safe, resilient and sustainable cities and human settlements, with the goals set therein addressing issues affecting sustainability 11.3 and 11.c ; and with SDG 9 - Industry, innovation and infrastructure - Building resilient infrastructure, promoting inclusive and sustainable industrialization, and fostering innovation and specifically with goal 9.4 that deals with the modernization of infrastructure and rehabilitation of industries to makesustainable; and 9.5 which addresses the strengthening of scientific research, and improvement of technological capabilities of industrial sectors.

3 METHODOLOGY

This research, in terms of its nature, is classified as applied, exploratory, with a qualitative approach (GIL, 2019) and with the use of the bibliographic research method in the databases of the CAPES Catalog of Theses and Dissertations; and application of the Content Analysis technique (BARDIN, 2011). This study continues the findings of Checcucci (2019), on Teaching and Learning of BIM in the period from 2013 to 2018, who, based on his research, presented the existence of 4 doctoral theses and 8 master's dissertations in the teaching category, in this period, since they were productions on the study of BIM in higher education institutions or courses, totaling 12 productions carried out in 7 Brazilian states, Bahia, Espírito Santo, Paraná, Rio de Janeiro, Rio Grande do Norte, Santa Catarina, São Paulo and the Federal District. None of the states in the North and Central-West regions (except the Federal District) of the country.

As studied by Checcucci (2019), the research method she used consulted the CAPES Theses and Dissertations Catalog using the terms BIM, "Building Information Modeling" and "Building Information Modeling", filtered by the major areas of knowledge of Exact and Earth Sciences; Applied Social Sciences; Engineering and Multidisciplinary. The filter for specific areas of knowledge of Public Administration; Architecture and Urbanism; Civil Construction; Civil Engineering; Production Engineering; Engineering, Technology and Management; Social Sciences and Humanities and Architectural and Urbanism Technology was also used. After this survey, it was possible to filter the works that were related to the category of BIM teaching in institutions, courses, disciplines worked, among other topics related to teaching and learning, the object of this study.

Given the relevance of the research in the context of teaching and learning the BIM methodology, this research sought to expand the findings by Checcucci (2019) up to 2018, expanding the temporal dimension with the years 2019 and 2020, using the same methodology, methods and database used by her in her research, thus ensuring that the results obtained could reflect the same basis and present coherence in their analysis.

4 RESULTS AND DATA ANALYSIS

4.1 –Data Selection and Constitution of the Sample Universe

The analysis of theses and dissertations revealed a growing interest and recognition of the importance of teaching BIM in Brazilian HEIs. Of those published in 2019, it was possible to identify 59 dissertations and 11 theses on the topic of BIM, but only 2 specifically on teaching this methodology. In 2020, 64 productions were found, of which 4 dissertations and one thesis were in the teaching category.

It was thus possible to complement the figure presented by Checcucci (2019) of productions on the study of BIM in higher education institutions or courses, now covering the period from 2013 to 2020, totaling 19 productions carried out in 10 Brazilian states, Bahia, Espírito Santo, Mato Grosso, Minas Gerais, Paraná, Rio de Janeiro, Rio Grande do Norte, Rio Grande do Sul, Santa Catarina, São Paulo, and the Federal District. None of the states were in the northern region of the country, as shown in Figure 1.

Figura 1 – Pesquisas sobre Ensino e Aprendizagem de BIM – 2013 a 2020.
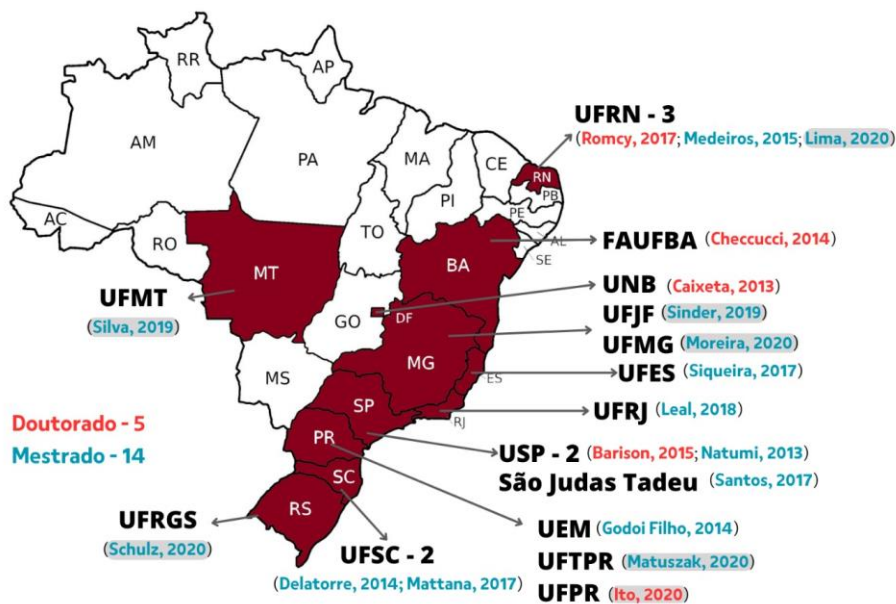
Source: Checcucci (2019, p. 10); Bonfante (2023).

The results show that although there is more research on BIM, there are still several challenges to be overcome, including the need to develop more specific teaching materials that address BIM learning. Training teachers, as well as promoting partnerships with the industry, given the practical relevance of teaching BIM, can represent factors that encourage and drive studies on the subject.

It is worth mentioning the aspect related to the research identified on teaching BIM in the country, with regard to the geographic distribution in which the research was carried out, which can be seen by observing Figure 1.

Although three new states, Mato Grosso, Minas Gerais and Rio Grande do Sul, incorporated the list of federation units that presented research on the subject, from the inclusion of the years 2019 and 2020, there is no uniform distribution of academic productions related to the subject in the country.

Checcucci (2019 p. 14) highlighted this situation as one of the main results of his research: "78.3% of the research found was produced in the south-southeast axis of the country and in educational institutions based in capitals and large cities, indicating the need for internalization and dissemination of BIM in other regions", a situation that continued.

Based on the theses and dissertations identified in the dimension of teaching practiced in the HEIs covered in those studies, it was possible to establish a basis for analysis regarding the use of the BIM methodology. Table 1 presents these works organized by year of publication, title, author, type of course in which it was produced (master's or doctorate), HEI to which it belonged or its author, and the federation unit of the institution.

Os resultados encontrados revelam que embora existam mais pesquisas sobre o BIM, ainda há diversos desafios a serem superados, incluindo a necessidade de desenvolvimento de material didático mais específico que aborde a aprendizagem BIM. A capacitação de docentes, assim como a promoção de parcerias com a indústria, dada a relevância prática do ensino do BIM, podem representar fatores que incentivem e impulsionem o estudo sobre o tema.

Cabe mencionar o aspecto relacionado as pesquisas identificadas sobre o ensino do BIM no país, no que se refere a distribuição geográfica em que as pesquisas foram realizadas, o que pode ser verificado ao se observar a Figura 1.

Embora três novos estados, Mato Grosso, Minas Gerais e Rio Grande do Sul incorporaram o rol das unidades da federação que apresentaram pesquisas a respeito, a partir da inserção dos anos de 2019 e 2020, não se constata uma distribuição uniforme das produções acadêmicas relacionadas ao tema no país.

Checcucci (2019 p. 14) ressaltou essa situação como um dos principais resultados de sua pesquisa "78,3% das pesquisas encontradas foram produzidas no eixo sul-sudeste do país e em instituições de ensino sediadas nas capitais e grandes cidades, indicando a necessidade de interiorização e difusão do BIM em outras regiões", situação que se manteve.

A partir das teses e dissertações identificadas na dimensão do ensino praticado nas IES tratadas naquelas pesquisas, foi possível constituir uma base para análise a respeito da utilização da metodologia BIM. O Quadro 1 apresenta esses trabalhos organizados pelo ano de sua publicação, título, autor(a), tipo do curso em que foi produzida (mestrado ou doutorado), IES a qual pertencia ou seu autor(a) e a unidade da federação da instituição.

Table 1 – Research on BIM Teaching and Learning in Brazilian HEIs – 2013 to 2020.

Ano	Título do Trabalho	Autor(a)	Nível	IES	UF
2013	Critical study on the use of three-dimensional modeling tools for digital information (BIM) in contemporary architecture teaching.	CAIXETA, L. M.	Doctorate	UNB	DF
2013	Teaching applied computing in undergraduate courses in architecture and urban planning in Brazil.	NATUMI, Y.	Masters	USP	SP
2014	Teaching and learning of BIM in undergraduate courses in Civil Engineering and the role of Graphic Expression in this context.	CHECCUCCI, É. S.	Doctorate	FAUFBA	BA
2014	Contributions to the Teaching of Architectural Design: Towards a New Paradigm.	GODOY FILHO, A. A.	Masters	UEM	PR
2014	Potentials and limits of BIM in architecture education: an implementation proposal.	DELATORRE, V.	Masters	UFSC	SC
2015	Integration of Architectural and Structural Design in teaching through BIM: an approach of the architecture and urban planning courses at UFRN and UFPB.	MEDEIROS, S. C. S.	Masters	UFRN	RN
2015	Introduction of building information modeling (BIM) into the curriculum: a contribution to designer training.	BARISON, M. B.	Doctorate	USP	SP
2017	Parametric approach and teaching of design: Proposition of methodological guidelines, considering curricular strategies and the design studio.	ROMCY, N. M. S.	Doctorate	UFRN	RN
2017	Building information modeling in architecture and urban planning teaching: Perception and dissemination of BIM in Higher Education Institutions in the State of São Paulo.	SANTOS, L. A.	Masters	USJT	SP
2017	Application of building information modeling (BIM) and problem-based learning (PBL) methodologies in the undergraduate civil engineering course / UFES: diagnosis and recommendations.	SIQUEIRA, L. S. R.	Masters	UFES	ES
2017	Contribution to teaching budgeting using BIM in quantity surveying.	MATTANA, L.	Masters	UFSC	SC
2018	Proposals for teaching architecture and urban planning content through digital tools.	LEAL, B. M. F.	Masters	UFRJ	RJ
2019	Computational Resources in the Teaching of Architecture and Urbanism: a Mapping of Course Content in Brazil.	SINDER, M. B.	Masters	UFJF	MG
2019	Rationalization of construction in architecture teaching: an analysis of undergraduate courses at public universities in Mato Grosso.	SILVA, M. R.	Masters	UFMT	MT
2020	Contributions of BIM Technology to the Teaching-Learning of Architectural Design with Emphasis on Technical-Construction Aspects.	SCHULZ, V. M.	Masters	UFRGS	RS
2020	The role of the University in the dissemination of BIM Technology: articulations between teaching modalities and the new paradigm of knowledge modeling.	MOREIRA, F. A. C. P.	Masters	UFMG	MG
2020	Proposal of an Educational Scenario for Teaching BIM from a Hybrid Teaching Perspective.	LIMA, W. E. F.	Masters	UFRN	RN
2020	Information model for acquiring the architectural repertoire of buildings of previous architecture.	ITO, A. L. Y.	Doctorate	UFPR	PR
2020	Lean Construction Practices: research into teaching in undergraduate civil engineering courses.	MATUSZAK, A. R.	Masters	UFTPR	PR

Source: Prepared by the authors based on Checcucci (2019); Bonfante (2023).

The reading of the selected academic papers made it possible to map the approaches taken by their authors regarding the teaching of BIM in HEIs, resulting from the content analysis

performed. We sought to identify outreach activities, characteristics of teachers and students, mandatory, elective or optional subjects, equipment in computer labs, partnerships with companies, training programs and specific software, among others.

The analysis of the papers presented in Table 1 revealed a predominance of themes focused on the implementation and teaching of BIM in undergraduate courses, especially in architecture and civil engineering. There is a significant emphasis on research that addresses the integration of this technology into the academic curriculum, highlighting the challenges and pedagogical strategies necessary for its adequate incorporation.

The paper entitled "Critical study on the use of three-dimensional modeling tools of digital information BIM in contemporary architecture teaching" reflects an interest in critically evaluating the tools and their practical applications in the educational environment. Another, such as "Integration of Architectural and Structural Design in Teaching through BIM: an Approach to Architecture and Urban Planning Courses", indicates a concern in associating the BIM methodology with interdisciplinary practice, integrating different components of the courses to optimize learning.

There are works that explore active teaching methodologies, such as Problem-Based Learning (PBL), aiming to increase student autonomy and promote a more practical and collaborative approach in the use of BIM. An example of this can be found in the work "Application of the building information modeling (BIM) and problem-based learning (PBL) methodologies in the undergraduate civil engineering course at the Federal University of Espírito Santo (UFES).

The topics covered demonstrate an effort to adapt the curricula and train teachers and students to use the BIM methodology, addressing technical and practical training aspects. This diversity of topics highlights an attempt to consolidate BIM as a necessary tool for the training of construction professionals in Brazil.

It is worth mentioning that the implementation of BIM in higher education is not limited to curricular adaptation alone, but involves the creation of learning spaces that favor the practice and development of technical skills, such as laboratories equipped with specific software and partnerships with companies in the sector. The practical experience provided by these environments will allow students to develop essential skills for professional practice.

The integration of BIM in undergraduate courses, especially in architecture and engineering courses, has the potential to transform the way future professionals perceive and act in the construction process. With the introduction of technologies that allow visualization and simulation of construction scenarios in real time, students gain a broader understanding of the impacts of their decisions from the initial design phase. This is in line with global trends in promoting sustainable practices related to the construction of inclusive cities and the modernization of infrastructure. Therefore, the adoption of BIM in Brazilian higher education not only modernizes the curriculum, but positions professionals in training as agents of change in the construction sector.

4.3 - Treatment of results: inferences and interpretations

The positive factors (strengths) were systematized and presented, those that justify the application of the methodology, therefore broadening, as well as producing important results resulting from its use; and the negative factors (weaknesses) or limits in the use of BIM, which can be characterized as challenges to be overcome by HEIs aiming at expanding the use of this resource in their courses. The results are presented in a summarized form in Table 2.

Table 2 – Results of Publications on BIM Teaching and Learning in Brazilian HEIs – 2013 to 2020.

Positive factors (strengths) - Amplifying	Negative factors (weak points) - Limiting
Recognition of technological evolution and its influence on architectural practice and the impact of digital tools on the architect's work.	Capacity of HEIs to provide laboratories with sufficient technological facilities to meet the demands for implementing BIM.
Identifying the trend towards introducing Building Information Modeling (BIM) shows that courses are adapting to new technologies, which is positive for the training of future professionals, as well as the development of skills to work with BIM.	The introduction of new technologies, such as BIM, implies a change in the way of teaching. Resistance or the need for additional training on the part of teachers can represent an obstacle, as well as on the part of students.
Inclusion of key concepts in the area of Education, such as multidisciplinarity, interdisciplinarity and transdisciplinarity, indicates an understanding of the importance of integrated approaches in the teaching of architectural design. It implies a change from a linear and fragmented process to a collaborative model.	The fact that some institutions offer three to fifteen Applied Computing subjects in the course may indicate a lack of consensus on what is essential for the training of professionals, which may result in curricular overload.
Discussion on active methodologies in higher education, such as PBL (Problem-Based Learning) and (Project-Based Learning), contributes to the educational debate, highlighting the importance of developing systemic and integrative thinking in students, as well as promoting greater autonomy in learning, meeting the expectations of new generations.	The lack of specific subjects in the curricular structure and the lack of knowledge of the necessary tools can limit the integration of a methodological proposal that adequately contemplates BIM.
Alignment with Market Expectations recognizing the importance of training professionals aligned with market expectations and creating a professional profile capable of effectively using BIM.	Changes in teaching proposals, especially the introduction of innovative methodologies, may face institutional resistance, requiring considerable efforts for their implementation.
Proposals for solutions and improvements in teaching, such as the inclusion of specific subjects with more advanced BIM skills, partnerships with engineering courses and the promotion of transdisciplinary integrations.	The results obtained with the BIM approach in the specific context of the construction technique may not be generalizable to all disciplines of these techniques or all phases of the design process.
The inclusion of pedagogical experiments, such as extension courses and optional subjects, demonstrates a practical approach to testing and adjusting the methodological guidelines proposed in BIM teaching.	Limitations in Practical Application resulting from the fact that few teachers carry out practical work in partnership with construction companies.

Source: Authors (2023)

It can be inferred from these results that there is a perception on the part of those involved in the context of undergraduate teaching in architecture and urban planning of the importance of developing professional skills that enable adequate professional qualification to work in this new model as required by the job market. However, there are still limiting conditions that represent barriers, but which can be overcome given the importance that this methodological work proposal proposes, and for which greater adherence is expected from all those involved in its teaching.

5 CONCLUSION

The results of this research highlighted the evolution of the field of study of BIM teaching in the Brazilian context. It is expected that it may represent an element of attention for educators, industry professionals and researchers in promoting education that is more aligned with the contemporary demands of civil construction.

The constant effort to develop innovative teaching methods and methodologies adapted to the specificities of the construction industry in the country is noticeable, based on the teaching and learning practices verified in the analyzed works, as well as on the proposal to adapt the national curricular guidelines for the architecture and urban planning course. However, challenges persist, highlighting the continuous need to develop practical teaching materials and train teachers to use the BIM methodology in their disciplines. In addition, the promotion of strong partnerships between educational institutions and the industry is essential to ensure that the knowledge transmitted is current and immediately applicable in the professional environment.

The findings of this study reinforce the importance of curricular adaptation and teacher training to ensure the effective insertion of BIM in Brazilian higher education institutions. The incorporation of emerging technologies and innovative methodologies is necessary to meet the contemporary demands of the labor market and society. Strengthening partnerships between academia and the production sector, especially in a scenario of increasing digital transformation, is essential to promote more practical training aligned with the needs of the construction sector. It is expected that such initiatives can contribute to this.

O resultado desta pesquisa destacou a evolução do campo de estudo do ensino do BIM no contexto brasileiro. Espera-se que possa representar um elemento de atenção para educadores, profissionais da indústria e pesquisadores em promover uma educação mais alinhada com as demandas contemporâneas da construção civil.

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