

Review

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Posted Date: 27 March 2026

doi: 10.20944/preprints202603.2206.v1

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Review

Integration of Building Information Modeling (BIM) in Higher Education: Analysis of Undergraduate and Graduate Curricula

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Abstract

The digital transformation of the Architecture, Engineering and Construction (AEC) sector requires human capital trained in collaborative methodologies. In Peru, the BIM Peru Plan establishes the mandatory nature of this methodology by 2030, posing a critical challenge for academia. This research analyzes and evaluates the proposal for curricular integration of the Building Information Modeling (BIM) methodology at the levels of technical, university and postgraduate higher education in Peru, in accordance with the regulatory framework in force to 2025. A qualitative research design of documentary and descriptive nature was used. A categorical content analysis of the national regulations was carried out, mainly R.D. No. 004-2025-EF/63.01, using as dimensions of analysis the fundamentals, modeling and management of information under the standards of the ISO 19650 standard. A didactic progression structured in three levels was identified: technical (operational/production), university (coordination/collaboration) and postgraduate (strategic management/direction). The transition from a software tool-based approach to one focused on information requirements management is highlighted. Curricular alignment with international standards (ISO 19650) is robust; however, a gap persists between the regulations and the installed capacity in universities. It is concluded that curricular standardization is a driver for interoperability in the public sector, recommending the implementation of interdisciplinary laboratories to mitigate disciplinary isolation.

Keywords: building information modeling (BIM); curricular innovation; digital skills; information management; BIM Peru Plan; ISO 19650

1. Introduction

The architecture, engineering, and construction (AEC) industry is undergoing an unprecedented digital transformation, driven by the convergence of technologies such as information modeling, cloud computing, the Internet of Things (IoT), and artificial intelligence (Vanlande et al., 2008; Becerik-Gerber et al., 2011). In this context, Building Information Modeling (BIM) has established itself as the predominant paradigm for information management throughout the life cycle of infrastructure projects. According to Supreme Decree No. 108-2021-EF, BIM constitutes “a collaborative work methodology for the management of information on a public investment, which makes use of an information model created by the parties involved to facilitate the multi-year programming, formulation, design, construction, operation and maintenance of public infrastructure, ensuring a reliable basis for decision-making” (MEF, 2021). This definition, adopted in the Peruvian legal system, underlines the methodological and collaborative nature of BIM, radically distinguishing it from a three-dimensional modeling computer application.

On a global scale, the adoption of BIM is extensive and growing. The UK, a pioneering country, has been requiring BIM maturity level 2 for public projects since 2016 (HM Government, 2012) and is moving towards Level 3 (Digital Built Britain). The Scandinavian countries – Finland, Norway,

Denmark – have consolidated mandates of decades. In southern and central Europe, Spain (Ministry of Public Works, 2015), France (Plan de Transformation Numérique), Germany and Italy have established mandatory calendars (Bortolini et al., 2019). The publication of the ISO 19650 series of standards (parts 1 and 2, 2018; part 3, 2020; part 5, 2020) by the International Organization for Standardization has provided a global framework for information management using BIM, independent of specific technology platforms, facilitating its multinational adoption (Siebelink et al., 2021).

In Latin America, the adoption of BIM in the public sector is progressively accelerating. Chile, through the MOP/MINVU BIM Plan, exhibits the highest degree of institutional maturity in the region, with consolidated university postgraduate programs and major infrastructure projects executed in BIM (Montava, 2021). Brazil, Colombia, Costa Rica, Mexico, and Uruguay have established national plans or strategies at different stages of implementation (Abdirad and Dossick, 2016). In this context, Peru has taken a step of singular importance by enrolling the BIM Peru Plan in the National Plan for Competitiveness and Productivity 2024-2030 (D.S. No. 203-2024-EF), establishing as a goal that the methodology will be mandatory for all public investments by 2030. Specifically, Supreme Decree No. 203-2024-EF sets intermediate milestones for December 2025 and July 2030 for mandatory application at the three levels of government.

Faced with this regulatory imperative, the training of human capital with BIM competencies becomes critical and urgent. However, the literature on BIM education consistently reports that the training offer lags structurally with respect to market needs (Clevenger et al., 2010; Lee & Hollar, 2013; Hjelseth, 2016). These lags are expressed in three dimensions: (i) the persistence of an approach focused on the management of modeling software, to the detriment of the understanding of BIM as a methodology for collaborative information management; (ii) the shortage of teachers with comprehensive BIM competencies; and (iii) fragmentation and lack of curricular coherence in the design of curricula (Succar et al., 2013; Abdirad & Dossick, 2016). In the Peruvian case specifically, by 2021 there were no master's degrees or doctorates with BIM as the central axis, the specialized offer was concentrated in Lima, and in the undergraduate program, integration was predominantly limited to the management of software in architecture careers (MEF, 2025).

Aware of this gap, the General Directorate of Multiannual Investment Programming (DGPMI) of the MEF developed, within the framework of the BIM Peru Plan, a proposal for an indicative curriculum for three educational levels: technical higher, undergraduate university and postgraduate university. This document, approved by R.D. No. 004-2025-EF/63.01, represents the first systematized exercise at the national level – and one of the few in Latin America – of BIM curriculum design linked to a public policy mandate. Its analysis is, therefore, of special relevance for the academic community and for decision-makers in education and infrastructure.

The research gap that motivates this study is twofold. First, the existing literature on BIM education focuses predominantly on European and Anglo-Saxon contexts with mature market frameworks, with little attention to countries that implement BIM as a mandatory public policy simultaneously with the formation of the human capital necessary to implement it (Hjelseth, 2016; Siebelink et al., 2021). Second, the curricular analyses available in the Latin American context are mostly descriptive and do not address the alignment between the training content and the real technical requirements that BIM projects demand from professionals, as established in the Information Exchange Requirements Registers (EIR) and the BIM Execution Plans (BEP).

The main objective of this article is to analyze the BIM integration models proposed in the undergraduate and graduate curricula by the MEF, identifying the competency progression by academic level, the articulated technical standards and the implementation gaps detected. As a secondary objective, it seeks to evaluate the degree of alignment between the curricular proposal and the real technical-professional requirements documented in BIM pilot projects of the Peruvian public sector, thus contributing to an informed discussion on the relevance of the training offer with respect to the labor market.

2. Methodology

2.1. Study Design

The study adopted a documentary research design with a methodological approach of qualitative content analysis (Bardin, 2002; Krippendorff, 2004). This approach is relevant when the objective is to systematically examine the meaning, structure, and implications of normative and technical texts, allowing reproducible and valid inferences to be drawn about their characteristics (Krippendorff, 2004). Unlike empirical studies that evaluate the actual implementation of BIM in classrooms, this analysis focuses on the structure and internal coherence of the official curriculum proposal and its alignment with national and international regulatory frameworks. This delimitation constitutes simultaneously an explicit limitation of the study –which is discussed in the corresponding section– and a methodological decision justified by the novelty of the analyzed proposal, which is still in the initial stages of pilot implementation.

2.2. Documentary Corpus and Selection Criteria

The corpus of analysis was formed by intentional sampling of official primary documents (Patton, 2002), following the inclusion criteria: (a) direct relevance to the object of study (BIM training in HEIs or BIM regulatory framework in Peru); (b) official character (issued by the MEF, INACAL or a competent public entity); (c) validity at the time of analysis (2019–2025); and (d) public availability. Secondary documents (newspaper articles, unofficial institutional presentations) and repealed regulations were excluded. Table 2 describes the resulting corpus.

Table 2. Documentary corpus analyzed.

Document	Legal instrument	Year	Type	Role in analysis
BIM Curriculum – Proposal for the adoption of BIM in the curricula of HEIs in Peru	R.D. No. 004-2025-EF/63.01	2025	Normative-orientation	Main corpus: curricular design by levels, summaries, profiles and competencies
National BIM Guide: Information Management for BIM-Developed Investments	R.D. No. 0003-2023-EF/63.01	2023	Technical-normative	BIM, CDE, EIR, BEP, LOD/LOI Process Framework
Form No. 04: Register of Information Exchange Requirements – EIR (IE Pilot Project No. 4015, GRC)	CUI 2510818 (Regional Government of Callao)	2023	Technical-contractual	Triangulation: Real Professional Requirements for BIM in Public Investments
Terms of Reference – BIM Annex (IE Pilot Project No. 4015)	GRC – Office of Construction and Roads	2024	Contractual	Triangulation: required software, CDE, BEP structure,

Document	Legal instrument	Year	Type	Role in analysis
				BIM roles in real projects
Guidelines for the Progressive Adoption of BIM in the Phases of the Investment Cycle	R.D. No. 0007-2022-EF/63.01	2022	Normative	Framework of four stages of organizational maturity; Triangulation with curricular progressivity
Implementation Plan and Roadmap of the BIM Plan Peru	R.D. No. 0002-2021-EF/63.01	2021	Strategic	Context and justification of the BIM Plan Peru; strategic lines; 2030 Goals
Supreme Decree No. 108-2021-EF	Amendment of D.S. N.º 289-2019-EF	2021	Legal	Official definition of BIM in the Peruvian legal system
Supreme Decree No. 203-2024-EF	PNCP 2024-2030 Update	2024	Legal-strategic	Milestones of mandatory BIM to 2025 and 2030; Macropolitical context

Methodological triangulation—the simultaneous inclusion of curricular, normative, technical, and contractual documents—is the most differentiating feature of design. Specifically, the incorporation of Form No. 04 (EIR) of the IE Pilot Project No. 4015 of the Regional Government of Callao and the BIM Terms of Reference of the same project made it possible to contrast the proposed training contents with the BIM performance requirements that the public procurement system effectively imposes on professionals in real projects, providing the analysis with a dimension of content validity that purely curricular analyses do not usually incorporate.

2.3. Analysis Procedure

The content analysis was developed in four sequential stages (Bardin, 2002):

(1) Pre-analysis. Exploratory reading of the corpus, delimitation of units of analysis (paragraphs, tables, sections) and construction of the provisional code book.

(2) Thematic coding. Identification and labeling of registration units in four analytical categories: (a) graduation profile and declared competencies; (b) areas of knowledge and structure of the curricula; (c) articulated tools, standards and methodological frameworks; and (d) implementation gaps and challenges. Coding was carried out independently by both authors and discrepancies were resolved by consensus.

(3) Construction of comparative matrices. Elaboration of comparison matrices between the three academic levels, between the curricular proposal and the real EIRs, and between the Peruvian proposal and international models documented in the literature.

(4) Interpretation and synthesis. Derivation of patterns, progressions and gaps from the cross-reading of the matrices, triangulating with the international literature on BIM education and information management in AEC projects.

The reliability of the process was guaranteed through: (i) triangulation of sources (curricular, technical and contractual documents); (ii) independent coding with subsequent verification of the agreement between coders; and (iii) explicit referencing of citations to the source documents in each unit of analysis. The criterion of thematic saturation was adopted as an indicator of the sufficiency of the corpus.

3. Results

3.1. Curricular Architecture by Academic Level: Progression from Modeling to Strategic Leadership

The analysis of the MEF's curricular proposal (2025) reveals a training architecture in three articulated levels, based on three cross-cutting areas of knowledge: (1) BIM Fundamentals, (2) BIM Information Modeling, and (3) Integrated and Collaborative Project Management. These areas are expanded in the postgraduate program with two additional areas: (4) Change Management and (5) Research. Table 1 presents the multidimensional comparison of the three curricular meshes.

Table 1. Multidimensional comparison of BIM curricula by academic level (MEF, 2025).

Dimension	Higher Technical Level	Undergraduate University	Postgraduate University
Duration	3 years / 6 semesters	5 years / 10 semesters	Diploma / Master's / Doctor (1–3 years)
Estimated BIM credits	~37 credits (compulsory + elective)	~55 credits (compulsory + elective)	~42 Specialized Credits
Graduation profile	Model, integrate, document and interpret BIM (architecture, engineering, construction) information	Conceive, design, coordinate, plan and integrate multidisciplinary projects in BIM	Manage change, drive innovation, and lead complex infrastructure BIM projects
BIM dimensions addressed	3D (modeling), 4D (time), 5D (costs)	3D, 4D, 5D, 6D (sustainability/eco-efficiency)	Asset management (lifecycle), collaborative contracts, public investment BIM
Areas of knowledge	BIM Information Modeling; BIM Fundamentals; Integrated and	BIM Information Modeling; BIM Fundamentals; Integrated and	BIM Information Modeling; BIM Fundamentals; Change Management; Integrated and

	Collaborative Management	Collaborative Management	Collaborative Management; Research
Key Courses	Architecture, BIM Basics, Documentation I-IV, Regulations & Standards, Collaborative Platforms, I-II Interoperability, Approach & Schedule, Costs & Budgets	BIM Basics, BIM Methodology Workshop, Integration of BIM Models, Construction Processes with BIM, Planning and Schedule, Management Model, Cost Management, Sustainability Concepts, Interoperability I-III, Documentation I-V	BIM Fundamentals, Planning and Costs, BIM Methodology Workshop, Collaborative Workshop, Management Workshop, Information Generation in BIM Models, BIM Control and Audits, BIM Digital Tools, Asset Management (design, construction, operation and maintenance), Collaborative Contracts, BIM Management in Public Investments, Research Seminars I-II
Tools / Software	Revit (architecture, fabrics, MEP), AutoCAD, Navisworks, S10, MSPProject, CDE (BIM Collaborate Pro) platforms	Revit, Navisworks, MSPProject, S10, CDE platforms, IFC tools, Lean 4D software	Cloud BIM (CDE) collaborative platforms, model auditing and review tools, asset management software
Standards and regulatory frameworks	NTP-ISO 19650 (INACAL), RNE, ISO BIM internacional, Plan BIM Perú	NTP-ISO 19650, PMBOK, Lean Construction, VDC, IPD, openBIM, RNE	ISO 19650 (complete), ISO 55001 (assets), NEC/FIDIC/G2G contracts, SNPMGI (Peru)
Key generic competencies	Oral and written communication; collaborative teamwork; Learning autonomy	Effective communication; collaborative work with ethics; situational leadership; self-learning; Sustainability	Strategic communication; results-oriented collaborative work; change leadership; assertive decision-making; Professional ethics

Key specific competencies	BIM modeling and interpretation; ICT management, BIM and CDE software; Technical knowledge of projects	Design, coordination and strategic planning in BIM; ICT, software and CDE domain; legal, economic and financial understanding; problem solving; Proposal of sustainable solutions	Strategic BIM information management; ICT and CDE management; holistic legal-technical-financial integration; Management of sustainable and comprehensive solutions
Investigative component	Not contemplated	Not contemplated (implicit in integrative projects)	Research Seminars I and II with development of applied thesis
Self-assessment guidance	Performance indicators by competence; Matrix of course-competence interrelations	Performance indicators by competence; matrix of interrelations; Evaluation of the Graduation Profile	Performance indicators by competence; matrix of interrelations; Institutional self-assessment with monitoring template and risk matrix

Note. Estimated credits are calculated by adding the credits of the required BIM courses and the potentially elective ones reported in the proposed curriculum. CDE = Common Data Environment; BEP = BIM Execution Plan; IFC = Industry Foundation Classes; VDC = Virtual Design and Construction; IPD = Integrated Project Delivery; openBIM = buildingSMART International interoperability standard; LOD = Level of Development; LOI = Level of Information.

3.2. Analysis by Level of Progression

3.2.1. Higher Technical Level

Structured in four semester levels, this level prioritizes operational competencies of graphic representation (Architecture and Engineering), interoperability of formats (buildingSMART IFC), 4D planning (Approach and Schedule) and 5D cost control (Costs and Budgets). The normative dimension is introduced in the second semester through the subject of Regulations and Standards, which covers the National Building Regulations (RNE), the ISO BIM standards and the Peruvian Technical Standards derived from ISO 19650 prepared by the National Institute of Quality (INACAL). The Documentation subjects (I–IV) act as an integrating axis of the production of information in each semester cycle, linking technical content with the development of structured BIM deliverables. Two Interoperability subjects (I and II) consolidate 4D and 5D workflows, respectively. The estimated BIM credit load amounts to 37 credits, distributed between mandatory and elective.

The internal progression of the technical level follows a logic of increasing complexity: from architectural modeling (level I) to structural and facility modeling (level II), to BIM planning and construction sequences (level III), and cost control (level IV). This design is consistent with the professional role expected of the technical graduate: qualified BIM operator capable of producing and managing information in models within multidisciplinary teams.

3.2.2. Undergraduate University Level

The proposal contemplates five annual levels with a progressively complex credit load (3–4 credits per specific BIM subject). The first level reproduces the initial structure of the technical level (Architecture, BIM Basic Concepts, Documentation I), although with a more explicit awareness-raising orientation on the need to adopt new methodologies. The second level introduces the BIM Methodology Workshop —an articulating subject of the undergraduate degree—, in which the BIM Execution Plan (BEP), collaborative workflows and the CDE are worked on (MEF, 2025). This subject establishes the conceptual bridge between technical modeling and methodological management of information, differentiating the undergraduate proposal from the purely operational one of the technical level.

The third level incorporates the multidisciplinary Integration of BIM Models, the analysis of interferences and incompatibilities and Construction Processes with BIM under the Lean Construction approach. The fourth level links BIM with comprehensive project management (Project Management Model, PMBOK, VDC, IPD) and with 5D cost control (Costs and Budgets, Cost Management). The fifth level culminates with BIM 6D sustainability management – energy analysis and eco-efficiency (Sustainability Management, Sustainability Concepts) – and introduces the openBIM paradigm. The distribution of elective subjects (Documentation I–V, Architecture) gives HEIs flexibility to adapt to their own current curricula, operationalizing the proposed principle of progressivity.

3.2.3. Postgraduate University Level

Structured in five levels, this level shifts the focus of modeling to strategic information management and organizational change. The first level brings together the methodological foundations (BIM Fundamentals, BIM Methodology Workshop, Planning and Costs). From the second level, the Collaborative Work and Management Skills workshops introduce high-order soft skills (leadership, coaching, strategic thinking, emotional intelligence) articulated with BIM management. The third level incorporates subjects of BIM Digital Tools, BIM Control and Audits, and Asset Management in Design and Construction – the latter aligned with ISO 19650-2 for information exchange processes in the design and construction phases. The fourth level integrates collaborative platforms BIM in the cloud, BIM Standards and Regulations, Research Seminar I and Asset Management in Operation and Maintenance (ISO 55001) and Change Management and Innovation I. The fifth level closes with Collaborative Contracts (IPD, NEC, FIDIC, G2G) and BIM Management in Public Investments —articulating the framework of the National System of Multiannual Programming and Investment Management (SNPMGI)—, in addition to Research Seminar II, which leads to the support of an application thesis.

3.3. Alignment with Real Technical-Professional Requirements (EIR-Curriculum Triangulation)

The triangulation of the curricular corpus with the EIR and the TDRs of the IE Pilot Project No. 4015 (GRC, 2023–2024) reveals a high degree of curricular relevance of the MEF proposal. Form No. 04 EIR establishes 31 deliverable products organized into five milestones (Definitive BIM Execution Plan, Architectural Preliminary Project, Design of Specialties and Compatibility, Obtaining Measurements, Programming and Budget, and Complete Technical File), which require competencies directly corresponding to the contents proposed in the curriculum. Table 3 presents the alignment between the curricular areas, the specific competencies, the tools required in the EIR and the reference standards.

Table 3. Alignment between BIM curriculum areas, actual EIR requirements, and regulatory frameworks.

Area of knowledge	Core Specific Competence	Tools / Software (EIR/TDR)	Standard / Regulatory Framework
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BIM Information Modeling	Interpret and generate graphic and alphanumeric information on infrastructure projects	Revit 2023, Robot Structural, ETABS, SAFE, AutoCAD Civil 3D	NTP-ISO 19650 Pt. 1 & 2; BIM Technical Guide (MEF); LOD/LOI according to BEP
BIM Fundamentals	Know the BIM regulatory framework and the principles of collaborative work	Autodesk Docs, BIM Collaborate Pro, Zoom / Teams / Meet	D.S. No. 108-2021-EF; D.S. No. 203-2024-EF; NTP-ISO 19650 (INACAL)
Information Management (CDE)	Manage the flow of information in the Common Data Environment (CDE) according to the BEP	BIM Collaborate Pro / Autodesk Construction Cloud; IFC-compliant cloud platforms	National BIM Guide (MEF, 2023); ISO 19650-2 (publish, share, archive); EIR-TDR of the project
Integrated Project Management (4D/5D)	Plan and control deadlines and costs using information models linked to schedule and budget	Navisworks 2023, MSProject, S10, Costit; formato .mpp / .xls / .nwf	PMBOK (PMI); Lean Construction; VDC; BIM Execution Plan (BEP-Definitive)
Interoperability and Open BIM	Exchange information across disciplines using open IFC formats and interoperability standards	IFC 2x3; .rvt, .nwc, .nwd, .nwf; Navisworks; exportadores IFC de Revit	buildingSMART International – IFC schema; openBIM; NTP-ISO 19650
Asset Management and Sustainability (6D)	Manage the life cycle of the built asset by applying sustainability and eco-efficiency criteria	Revit (energy analysis), 6D BIM software; MEP and energy simulation tools	ISO 55001; openBIM; Lean Construction; contratos NEC / FIDIC / G2G; IPD
Change Management and Research (Postgraduate)	Lead organizational transformation towards BIM; Producing applied knowledge through research	Advanced collaborative platforms (CDE in the cloud); BIM audit and control tools	ISO 19650 (complete); D.S. No. 289-2019-EF; MEF 2022 Guidelines; SNPMGI

Note. EIR = Exchange Information Requirements; BEP = BIM Execution Plan; CDE = Common Data Environment; LOD = Level of Detail; LOIN = Level of Information; MEP = Mechanical, Electrical and Plumbing; SNPMGI = National Multiannual Programming and Investment Management System.

The analysis of the EIR allows us to identify that Output 1 (Definitive BEP) requires competencies developed in the BIM Methodology Workshop (undergraduate) and in the BIM Fundamentals (postgraduate), including the ability to develop the Matrix for the Definition of the Level of Information Needed (LOIN), the General Information Development Program (MIDP) and the Information Development Program of a Task (TIDP) – documents explicitly linked to ISO 19650-2—. The Interoperability subjects (technical and undergraduate levels) respond directly to the requirement of exchange in IFC 2x3, .nwc and .nwd formats specified for Products 10 and 11. The software requirements – Revit 2023, Structural Robot, ETABS, SAFE, Navisworks, S10, MSPProject, AutoCAD Civil 3D, BIM Collaborate Pro – are covered by the Modeling and Interoperability subjects at the technical and undergraduate levels (see also Table 1). In short, triangulation empirically validates the relevance of the curriculum, while pointing out that the gap between training and practice does not lie so much in the proposed contents as in the speed of institutional implementation of these contents.

3.4. Tools, Standards and Methodological Frameworks Identified

The analysis of the corpus identifies four families of technical references articulated in the curricular proposal:

- National and international normative standards: ISO 19650 series (parts 1–5), adapted to the Peruvian context as NTP-ISO 19650 by INACAL (approved by R.D. No. 004-2021-INACAL/DN); ISO 55001 (asset management); National Building Regulations (RNE); National BIM Guide (MEF, 2023); BIM Technical Guide for Buildings and Infrastructure (MEF).
- Interoperability formats: buildingSMART International's IFC (Industry Foundation Classes) as an openBIM standard for cross-platform information exchange; .rvt, .nwc, .nwf, .nwd, .mpp, .xls formats for interoperability between modeling, review, and programming software.
- Project management frameworks: Lean Construction (Last Planner System, worktrains); VDC (Virtual Design and Construction); IPD (Integrated Project Delivery); PMBOK (Project Management Institute); BEP as a pedagogical and contractual tool.
- Collaborative contractual frameworks: NEC (New Engineering Contract), FIDIC (Fédération Internationale des Ingénieurs-Conseils), G2G (Peruvian government-to-government modality) – addressed exclusively at the graduate level.
- BIM dimensions: 3D (geometry and coordinates), 4D (time planning/MSPProject–Navisworks), 5D (costs/S10–Costit), 6D (sustainability and eco-efficiency), with implicit mention of the dimension 7D (operation and maintenance of assets) at the postgraduate level.

3.5. Gaps and Challenges Identified

The sources analyzed explicitly recognize three interrelated categories of challenges for the implementation of the curriculum:

(a) Involvement of institutional authorities. Curricular adoption is a long-term process whose sustainability requires the formal support of rectors, vice-rectors, deans and heads of schools, materialized in institutional normative instruments (resolutions, directives, curriculum modifications). Without this support, the integration of BIM is subject to individual initiatives by teachers, exposed to discontinuity due to staff turnover or management changes (MEF, 2025). The MEF's four-stage model—Planning, Implementation, Measurement and Monitoring, and Feedback (R.D. No. 0007-2022-EF/63.01)—provides a structured roadmap for this process, which can be extrapolated to HEIs.

(b) Generation of capacities in the teaching staff. The shortage of teachers with BIM skills who understand the methodology in its collaborative dimension – beyond the use of software – is

identified as the main operational bottleneck. The source documents explicitly state that teacher training must integrate technical-methodological knowledge with active pedagogical techniques (project-based learning, interdisciplinary collaborative work). It is also highlighted that the adoption of BIM concepts can be initiated in a transversal way in existing subjects before the formal approval of a new curriculum, thus reducing the dependence on a complete curricular reform.

(c) Development of technological infrastructure and collaboration laboratories. Deploying labs that simulate real CDE environments—with access to licensed BIM software, high-performance hardware, and collaborative cloud platforms—represents a significant investment. The TORs of IE Pilot Project No. 4015 specify minimum hardware requirements (3.5 GHz+ CPU, 16–32 GB RAM, SSD, 4–8 GB dedicated GPU) and active software licenses (Revit, Navisworks, Robot Structural, BIM Collaborate Pro, among others), which allow quantifying the technological standard to which the training should aspire. The documents analyzed highlight the availability of educational licenses from vendors such as Autodesk and Bentley to mitigate this cost.

In addition, a fourth gap is identified, implicit in the documents, but of high strategic relevance: geographical concentration. The significant BIM training offer in Peru continues to be concentrated in Lima, while the regions with the largest public infrastructure gap – and, therefore, with the greatest need for competent BIM professionals – remain underserved. This asymmetry reproduces patterns of territorial inequality that contradict the objectives of the BIM Peru Plan and the National Competitiveness and Productivity Plan.

4. Discussion

4.1. Positioning of the Peruvian Model in the Global Panorama of BIM Education

Compared to the international trends documented in the literature, the MEF's proposal exhibits a strategically solid positioning. In the European context, the leading countries in BIM education (United Kingdom, Spain, France, Italy) integrate the methodology predominantly in postgraduate programs as a management methodology, while in undergraduate the inclusion is limited to basic concepts in critical subjects of architecture and civil engineering (Hjelseth, 2016; Abdirad & Dossick, 2016). The American approach, represented by universities such as Stanford, tends to treat BIM as a technological instrument within courses and diploma courses, without necessarily articulating it with the collaborative philosophy of the project life cycle (Clevenger et al., 2010). The Peruvian proposal is aligned with the European model by explicitly and consistently adopting BIM as a collaborative methodology at all levels, consistent with the definition of D.S. No. 108-2021-EF and with the requirements of the ISO 19650 series.

A differentiating element with respect to other countries in the region is the systemic nature of the proposal: it is not an isolated university initiative, but a curricular model emanating from the governing body of the national public investment system (DGPMI-MEF), aligned with a mandatory regulatory mandate. In Chile, a Latin American benchmark, university-level BIM education emerged mainly at the initiative of public universities in response to government impulse, without there being an explicit curricular design of national scope (Montava, 2021). The Peruvian experience constitutes, in this sense, a model of curricular governance that deserves academic and comparative attention.

4.2. Theoretical Implications: Information Management as the Articulating Axis of the AEC Curriculum

From a theoretical perspective, the proposal analyzed proposes a reformulation of the articulating axis of the curriculum in AEC careers: the transition from a model focused on disciplinary technical competence (structural design, architectural design, facilities) to a model focused on the collaborative management of information as a transversal and integrating competence. This reformulation is consistent with the approaches of Succar and Kassem (2015), who propose that organizational BIM maturity depends critically on the ability to manage information throughout the asset's life cycle, not just in design or construction phases.

The progression of the three areas of knowledge (BIM Fundamentals → BIM Information Modeling → Integrated and Collaborative Project Management) replicated in the three educational levels with increasing complexity and abstraction reflects a constructivist logic of scaffolding (Vygotsky, 1978): the contents are introduced in an operational way (technical level), consolidated in an integrated methodological framework (undergraduate) and projected towards strategic leadership (postgraduate). This architecture is consistent with the competency progression frameworks proposed by Bloom (1956/2001) in his revised taxonomy, specifically in the remember-apply-analyze-create sequence that cuts across all three levels.

An additional theoretical contribution of the analysis lies in the identification of the alignment between the curriculum and the real EIRs as an indicator of curricular relevance. The literature on competency-based curriculum design (Jonassen et al., 1999; Biggs & Tang, 2011) emphasizes the importance of constructive alignment between learning objectives, training activities, and assessment. This study extends this principle to the level of professional relevance: the alignment between the curriculum and the performance requirements of the market (operationalized here as EIR/BEP) constitutes a dimension of curricular quality that accreditation systems in the AEC field should explicitly incorporate.

4.3. Practical Implications for National Education Policy

The findings have direct practical implications for actors in the education system and the public investment system. For HEIs, the alignment between the proposed curriculum and the actual EIRs provides an evidence-based argument to justify to institutional authorities the need to reform curricula: the curriculum does not respond only to an abstract government mandate, but to concrete and verifiable technical requirements that the labor market already demands. For the MEF, the results reinforce the relevance of continuing the piloting process in public universities and investing in teacher training as an enabling condition for curricular reform. For the Ministry of Education (MINEDU) and the National Superintendence of University Higher Education (SUNEDU), the results suggest the need to incorporate BIM maturity indicators in the licensing and accreditation processes of engineering, architecture and construction programs.

From a territorial equity perspective, the results reinforce the urgency of decentralising the BIM training offer. A viable strategy, suggested by the documents analyzed, is the development of teacher training programs in regional universities, combined with the availability of CDEs accessible in the cloud and educational software licenses, which reduce dependence on centralized physical infrastructure.

4.4. Adequacy of Current Models and Impact on Employability

The findings suggest that current BIM education models in Peru, while insufficient in terms of actual coverage and implementation, are structurally sound in their proposed design. The employability of graduates in the new labor market linked to public BIM investments depends on their ability to manage alphanumeric information (LOI) and not only geometric information (LOD), and to operate effectively in interdisciplinary CDE environments. The generic competencies proposed – effective communication, leadership, problem solving, sustainable thinking – respond directly to this demand, which is also documented in the BIM role profiles (BIM Coordinator, BIM Modeller, BIM Specialist) required in the TORs of the pilot project analysed.

The integration of frameworks such as Lean Construction, VDC and IPD at undergraduate and postgraduate levels is especially relevant from the perspective of employability and sectoral productivity. International studies have documented that the BIM-Lean combination produces significant synergies in reducing waste and improving productivity on site (Sacks et al., 2010). The curricular inclusion of these methodologies positions graduates as agents of transformation of construction processes, beyond the role of software users, and is consistent with the vision of the BIM Peru Plan to contribute to the reduction of the number of paralyzed public works (2,648 as of September 30, 2024, according to the Comptroller General of the Republic, 2024).

4.5. *The Principle of Progressivity as a Conceptual Contribution*

A significant conceptual contribution of the analyzed proposal is the operationalization of the principle of progressivity as the guiding axis of both BIM adoption in the public sector (D.S. No. 289-2019-EF; MEF Guidelines, 2022) and curricular transformation in HEIs. It does not propose a total and immediate renewal of the curriculum, but a gradual inclusion that respects the institutional autonomy and operational capacity of each study center. This reduces resistance to change and allows for transferable lessons learned. This approach is consistent with the literature on curricular innovation in higher education, which warns that reforms imposed without faculty participation and without adequate resources tend to fail (Fullan, 2007; Ellsworth, 2000).

The proposal also includes specific institutional self-assessment tools (monitoring template with weighted evaluation criteria) and specific risk management matrices for the adoption of BIM curricula. This provision of monitoring instruments is an innovative feature compared to other curricular proposals in the region, which are generally limited to describing content without providing mechanisms for monitoring implementation.

4.6. *Limitations of the Study*

The present study has four limitations that should be considered when interpreting its conclusions. First, the analysis is fundamentally documentary: it evaluates the internal coherence and relevance of the curricular proposal, but not its real effectiveness in the formation of BIM competencies, which can only be determined through longitudinal studies of follow-up of graduates or classroom evaluations. Second, the corpus, although comprehensive with respect to Peruvian regulations, does not include a systematic analysis of the current curricula of the Peruvian HEIs participating in the pilot (UNMSM, UNSA, UNP, UNCP, UNT, UNI, UNACH), which prevents the evaluation of the specific gap between the proposed curriculum and the current curricula. Third, the triangulation with the EIR is based on a single pilot project (IE No. 4015, GRC), which, although representative of projects in the education sector, may not capture the diversity of BIM requirements in other sectors (health, transport, sanitation). Fourth, the study does not address the gender dimension in the adoption of BIM in higher education, a variable that emerging literature points to as relevant for equity in the digital transformation of the AEC sector.

4.7. *Originality and Contribution to the Field*

The contribution of this study to the field of information management education in AEC projects is threefold. First, it is the first published academic analysis of the BIM curricular proposal of the Peruvian MEF (R.D. No. 004-2025-EF/63.01), an unprecedented model in Latin America due to its explicit articulation with a mandatory public policy. Secondly, the methodology of triangulation between curricular proposals and real EIR of projects is a novel methodological approach that can be replicated in other national contexts to assess the curricular relevance of BIM education. Third, the comparative multidimensional analysis (Table 1) and the competency-tool-standard alignment matrix (Table 3) constitute transferable analytical instruments for the revision of BIM curricula in other HEIs in the region.

5. Conclusions

The integration of BIM in Peruvian higher education is a strategic and non-extendable imperative, given the progressive obligation established by the State for 2030. The following conclusions can be drawn from this analysis:

First. The MEF's BIM curriculum proposal (2025) offers a structured, coherent and staggered model that articulates the three levels of higher education around a deliberate competency progression: from the technical-operational competencies of the technical higher level (modeling, documentation, 3D–5D interoperability) to the planning, multidisciplinary coordination and methodological innovation skills of the undergraduate (BIM 6D, Lean Construction, VDC, IPD,

PMBOK), and finally towards strategic leadership of organizational change, auditing, asset management and research in postgraduate studies. The focus on BIM as a collaborative methodology – and not as software – aligns the proposal with the international standards ISO 19650 and with the best European educational practices documented in the literature.

Second. The triangulation between the proposed curriculum and the actual EIRs of pilot projects in the Peruvian public sector reveals a high degree of curricular relevance: the contents, tools, standards and competencies described in the mesh correspond directly to the technical-professional requirements that the public procurement system imposes on professionals in active BIM projects. This correspondence validates the curricular proposal as a pertinent formative response and also provides an evidence-based argument for the justification of curricular reforms before the institutional authorities.

Third. The three structural gaps identified – lack of institutional leadership, shortage of teachers with collaborative BIM competencies, and insufficient technological infrastructure – are critical constraints for implementation, but can be addressed progressively. The strategy of transversal introduction of BIM concepts in existing subjects, before the approval of a new curriculum, constitutes a first step of high viability that does not require formal curricular reform. The availability of educational software licenses and CDE platforms in the cloud significantly lowers the barrier to technological investment.

Fourth. The geographical concentration of the BIM educational offer in Lima represents a gap that amplifies inequalities in regional professional competitiveness and contradicts the national objective of strengthening the capacities of professionals linked to public investment throughout the territory. Public universities in regions with the greatest infrastructure gap have a differentiated responsibility and opportunity to lead this process of educational decentralization.

Fifth. The MEF's proposal represents an innovative curricular governance model in Latin America, as it is the first national BIM curriculum explicitly linked to a mandatory public policy mandate. This model, with its institutional self-assessment and risk management tools, offers a transferable reference for other countries in the region that face the challenge of aligning their education systems with the imperative of digital transformation in the AEC sector.

5.1. Recommendations

- For HEIs: Formalize the adoption of the BIM curriculum through dean's or school's resolutions, establishing a progressive and realistic roadmap aligned with the MEF's four-stage model (Planning, Implementation, Measurement, Feedback). Avoid total curricular reform as a first step; prioritizing transversal inclusion and teacher training.
- For the MEF-DGPMI: Expand the specialized technical support program to pilot HEIs, with emphasis on the training of BIM trainers and the evaluation of teaching competencies. Consider the creation of a national repository of BIM pedagogical resources (summaries, rubrics, case studies of real EIR projects) with open access for all HEIs in the country.
- For MINEDU and SUNEDU: Incorporate BIM maturity indicators and curricular relevance with respect to the EIRs of the market as criteria in the licensing and renewal processes of engineering, architecture and construction programs. Explore mechanisms for the academic recognition of BIM competencies certified by the MEF or international organizations (buildingSMART, Autodesk Certified Professional).
- For regional universities: Articulate with the BIM Network of Latin American Governments and with the seven pilot universities of the MEF (UNMSM, UNSA, UNP, UNCP, UNT, UNI, UNACH) to access materials, experiences and teaching resources already validated in the Peruvian context, reducing the cost and time of the institutional learning curve.
- For the AEC industry and the State: Establish university-business alliances for the use of real BIM projects as curricular case studies and for the access of students to productive CDE environments in the form of pre-professional internships, consolidating the academy-industry training cycle that the literature identifies as a determinant of the effectiveness of BIM education.

5.2. Future Lines of Research

- Longitudinal study (2025–2030) of impact evaluation of the curricular mesh implementation pilots in the seven selected public universities, measuring the acquisition of BIM competencies through validated instruments (e.g., BIM Maturity Index – BMI, adapted to the Peruvian context).
- Development and validation of an instrument for measuring educational BIM maturity (BIM-EDU Maturity Index) applicable to Peruvian and Latin American HEIs, which operationalizes the dimensions of process, personnel, infrastructure and strategy proposed in the MEF Guidelines (2022).
- Multinational comparative analysis of the effectiveness of BIM curricular integration models in Latin American countries with national plans (Peru, Chile, Colombia, Brazil), using curriculum-EIR alignment as an indicator of relevance.
- Research on the effects of BIM training on the employability and job performance of graduated engineers and architects in the context of Peruvian post-2025 public investments, through tracer studies.
- Analysis of gender and equity in the adoption of BIM competencies in Peruvian higher education: gaps in access, participation and valuation of digital competencies in the AEC sector according to gender and geographical origin.
- Design and implementation of pedagogical strategies for the teaching of BEP and CDE as collaborative learning tools in university environments, with evaluation of their effectiveness through action research methodologies.

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