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Revit-BIM as a Didactic Strategy to Foster Design Thinking in Civil Engineering Students at Areandina University

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Abstract– This is finished project examines the integration of Building Information Modeling (BIM) through Autodesk Revit as a didactic strategy to foster Design Thinking (DT) in nine academic subjects (315 students in Aqueduct, Hydraulics, Sewerage Systems, Drinking Water Treatment, Wastewater Treatment, Structural Mechanics, Construction I, Construction II, Statics and Mechanics of Materials) of civil engineering at Areandina. Regarding [1], a mixed-methods approach was employed, combining qualitative observation of classroom practices with quantitative assessment of student performance. The methodology emphasized collaborative project development, iterative modeling, and reflective analysis of design processes, [2]. Results indicate that Revit-BIM enhances spatial reasoning, interdisciplinary communication, and sustainability awareness, while strengthening technical competencies aligned with industry standards. The findings support the incorporation of BIM-based strategies into curricular design as a means of cultivating innovative and adaptive problem-solving skills in civil engineering education.

Palabras clave. Revit-BIM; Design Thinking; Civil Engineering Education; Didactic Strategy.

I. INTRODUCTION

A. International context

The integration of Building Information Modeling (BIM) into civil engineering education has become a global trend, reshaping how future professionals approach design, collaboration, and sustainability, citing [3]. Autodesk Revit, as one of the most widely adopted BIM platforms, provides students with immersive, model-based environments that strengthen spatial reasoning and interdisciplinary communication, [4]. International experiences demonstrate that BIM not only enhances technical proficiency but also fosters design thinking, enabling students to develop creative and adaptive solutions to complex engineering challenges. In this context, Areandina's adoption of Revit-BIM as a didactic strategy aligns with international educational practices that emphasize innovation, sustainability, and digital transformation in engineering curricula.

At the international level, BIM education initiatives highlight the importance of equipping students with tools that bridge theory and practice, preparing them for industry demands in architecture, engineering, and construction. Revit-BIM courses and certifications offered worldwide illustrate how structured pedagogical models can cultivate reflective learning and collaborative problem-solving, [5]. Moreover, access to educational licenses and specialized training platforms has expanded opportunities for students to engage with BIM technologies, democratizing advanced design resources across institutions. Thus, positioning Revit-BIM as a didactical strategy at Areandina contributes to the global discourse on engineering education reform, reinforcing the role of digital innovation in shaping resilient and future-ready civil engineers, [6]. Moreover, Design Thinking (DT) structures interdisciplinary university courses around empathy, ideation, and iteration, bridging silos like humanities, engineering, and health for real-world problem-solving. It promotes collaborative skills and innovation in higher education globally.

B. Local scaffolding

In Colombia, the incorporation of Building Information Modelling (BIM) into civil engineering education has gained significant momentum, reflecting the country's commitment to aligning academic training with global construction industry standards, citing [7]. Institutions such as the Universidad Tecnológica de Bolívar (UTB) have implemented specialized programs like the Diplomado BIM Revit para Ingeniería Civil, which emphasize the integration of digital modeling into project development and urban planning. Similarly, according to [8] the Instituto Tecnológico Metropolitano (ITM) has advanced training initiatives through its Diplomado Metodología BIM con formación en Revit MEP, designed to strengthen interdisciplinary collaboration and technical competencies among engineering and architecture students. These national efforts highlight the growing recognition of BIM as a pedagogical tool that fosters design thinking, innovation, and sustainability in civil engineering education.

Furthermore, Colombian universities have expanded their offerings to include virtual and hybrid programs that democratize access to BIM education. The Universidad Piloto de Colombia [9], for instance, has launched a Diplomado en Desarrollo de Proyectos en BIM con Énfasis en Revit y Navisworks, enabling students across the country to acquire practical skills in model-based project development. Complementing these initiatives, professional training platforms such as Konstruedu provide updated courses on Modelado BIM con Revit Arquitectura 2024, reinforcing the importance of continuous learning and adaptation to technological advances. Together, these national strategies demonstrate how Revit-BIM is being positioned not only as a technical resource but also as a didactical strategy to cultivate

Design Thinking (DT), preparing Colombian civil engineering students to address complex challenges in infrastructure and construction, [10].

C. Areandina concern

Implementing Revit-BIM as a didactic strategy to foster Design Thinking (DT) in civil engineering students at Areandina encounters significant challenges, primarily due to the steep learning curve associated with mastering BIM software, [11]. Students often struggle with the transition from traditional 2D CAD tools to Revit's parametric 3D modelling, which demands proficiency in complex workflows like family creation, data interoperability, and clash detection, leading to frustration and reduced engagement in early coursework. Additionally, limited access to high-performance hardware and licensed software at the institution exacerbates these issues, hindering hands-on practice essential for developing iterative design skills.

Faculty at Areandina face further troubles in curriculum integration, as packed civil engineering programs leave little room to embed BIM without displacing core subjects like structural analysis or geotechnics. Resistance from students with diverse skill levels, ranging from novices to those familiar with basic drafting, complicates standardized teaching, while the scarcity of localized Revit component libraries for Colombian infrastructure projects limits relevance to regional contexts. These barriers, compounded by ongoing software updates requiring constant retraining, risk undermining the strategy's goal of cultivating collaborative, empathetic design thinking, [12].

D. Didactical strategy

The proposed didactical strategy for implementing Revit-BIM in nine courses with 315 civil engineering students at Areandina involves a phased rollout across multiple cohorts to cultivate design thinking through hands-on parametric modelling. In the initial phase, foundational workshops introduce Revit basics, such as 3D modelling of structural elements like beams, slabs, and foundations, via project-based learning modules divided into small teams of 15-20 students per instructor. This scalable approach leverages cloud-based Revit licenses and university labs to ensure accessibility, with iterative assignments simulating real infrastructure projects like bridges or urban retaining walls, fostering empathy for multidisciplinary collaboration and rapid prototyping.

Subsequent phases integrate advanced BIM workflows, including clash detection, quantity takeoffs, and 4D/5D simulations, using peer-reviewed rubrics to assess design thinking competencies across the full 315-student population through pre- and post-implementation surveys. Faculty training via Autodesk certifications ensures consistent delivery, while hybrid online modules accommodate diverse schedules, culminating in capstone group projects shared via a central BIM execution plan.

This structured proposal minimizes resource strain by prioritizing open-source interoperability tools and student-led tutorials, ultimately equipping graduates for industry demands in sustainable civil engineering. According to [13], monitoring these tools and tutorials progress toward attainment is a critical component of self-regulation through three-phase cycle adjusted to Revit-BIM based didactical strategy in Fig. #1:

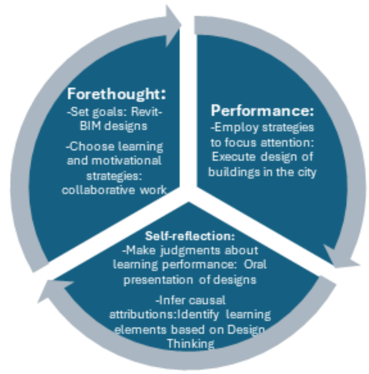

Fig. 1 Three-phase cycle of self-regulation.

That is, students are motivated to reduce the discrepancy they observe between their own performance with the Revit-BIM designs based on city buildings, and that provided by the standard or goal of construction requirements and standards set forth in the POT [14]. They take action by revising their self-beliefs, changing their goals, or changing their learning tactics regarding Revit-BIM designs.

The influence of context and consequences on students' continuing motivation to learn appears to be enhanced when students expectancies are satisfied and when they attribute their successes to their own efforts and effective learning strategies.

Students become increasingly self-regulated when they acquire skills to plan their learning, monitor their own progress, and evaluate the success of their efforts so as to improve their strategies in the future. Citing [15], the guidelines for facilitating the development of students' self-regulation are shown in the Table I:

TABLE I
GUIDELINES FOR STUDENTS' SELF-REGULATION

1. Provide opportunities for students to set their own designs in Revit-BIM and to manage the ways in which they attain those goals.
    - Learning goals are more effective than performance goals, and they should be challenging but attainable.
    - Modeling and directed reflection can help students choose effective strategies for learning, managing their time, and controlling the context surrounding learning.
2. Provide opportunities for self-appraisal.
    - Analyzing personal styles of learning and comparing them to others can increase students' awareness of different ways of learning.

- Monitoring progress: houses, buildings, roads designs can help students adjust strategies, allocate their efforts, and revise their goals.
- Periodic self-assessment can promote feelings of self-efficacy.

3. Create a reflective community.
    - The more opportunities and ways students can reflect on their learning and that of others, the greater the habit of self-regulation.

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[16] proposes a motivational model (ARCS) that provides a structured framework for enhancing learner engagement through four key components: Attention (arousal of curiosity), Relevance (meaningful connection to goals), Confidence (building self-efficacy), and Satisfaction (intrinsic and extrinsic rewards). DT [17], conversely, emphasizes an iterative, human-centered process of Empathize, Define, Ideate, Prototype, and Test to foster innovation and problem-solving. Articulating these theoretically reveals synergies where DT operationalizes ARCS principles, creating motivationally robust learning environments in educational design.

E. Core Components

[16] with ARCS model targets motivational deficiencies systematically, starting with Attention to capture interest via perceptual arousal (e.g., novelty to learn Revit-BIM) or inquiry stimulation (e.g., challenges). Relevance links content to students' past experiences, present needs, or future goals, while Confidence fosters efficacy through clear expectations and progressive success, culminating in Satisfaction from meaningful outcomes. DT mirrors this by grounding innovation in empathy (Attention/Relevance via user insights), problem definition (Relevance/Confidence via focused challenges), and rapid iteration (Confidence/Satisfaction through testable prototypes with designs).

F. State of the art

Several recent works have explored how Building Information Modeling (BIM) and related digital tools can be used to foster Design Thinking in architecture, engineering, and construction (AEC) education and practice. Below is a concise state of the art summary:

O'Reilly & colleagues (2024) propose a "BIM driven curriculum for integrated design studios" in which BIM is not just a drafting tool but a decision support backbone for evidence-based design thinking. Students systematically couple BIM models with energy simulation and life cycle assessment tools to generate and test alternative design scenarios. In a 2025 EC3 conference paper, researchers embed BIM into case-based learning (CBL) modules on energy and circular economy transitions, using the platform to scaffold Design Thinking like problem solving. Students use BIM models to represent real world constraints (e.g., retrofitting conditions, circular material flows) and co create solutions with peers and external stakeholders, stressing empathy, co creation, and system level thinking. On integrating parametric design (PD), generative design (GD), and BIM highlight how these tools can extend Design Thinking into computationally driven ideation. This approach reframes BIM not as a rigid constraint on creativity, but as a flexible "filter" that channels exploratory thinking toward technically and environmentally feasible outcomes. A 2025 industry oriented article frames Design Thinking as a "compass for innovation in BIM and construction," describing early design workshops where BIM is used to align conceptual models with user needs and context. A 2023–2024 study in the Netherlands proposes a Design Research Methodology based framework to enhance BIM education within a Built Environment program. BIM is embedded as a continuous, longitudinal component of students' professional development, requiring them to iteratively investigate real world "wicked problems" (e.g., energy transition retrofits) through model supported experimentation and reflection. BIM is increasingly treated as a platform for scenario exploration and performance based ideation, rather than a final documentation. Additional, Human centred BIM concept has Several studies foreground user empathy, co creation, and real world problem contexts, using BIM and immersive technologies (VR, CDE platforms) to maintain a people centred lens throughout the design process. And Interdisciplinary and systemic thinking approach, BIM driven curricula and CBL modules explicitly aim to break disciplinary silos, aligning Design Thinking practices with sustainability, circularity, and energy transition goals.Integrating ARCS into DT reframes the latter as a motivational scaffold: Empathy arouses Attention by immersing designers in real user curiosities; Define builds Relevance and Confidence by clarifying wicked problems; Ideation sparks inquisitive exploration; Prototyping enables low-risk Confidence-building trials; and Testing delivers Satisfaction via validated impact. This fusion posits motivation as emergent from human-centered iteration, where ARCS conditions converge iteratively rather than linearly, enhancing learner agency in complex, ill-structured domains like STEM education.

G. Practical Implications

This articulation supports hybrid interventions, such as ARCS-infused DT workshops, where empirical studies could measure outcomes via pre/post motivation scales (e.g., IMMS for ARCS) alongside innovation metrics (e.g., prototype viability). For instance, a curriculum might sequence empathy mapping (Attention) with user-goal alignment (Relevance), yielding higher persistence in prototyping phases. This theoretical bridge advances instructional design by embedding psychological motivation into creative processes.

The main gaps in how Revit BIM and Design Thinking are currently applied in civil engineering education at Areandina University. First, most BIM based curricula focus narrowly on technical Revit operations without embedding Design Thinking as an explicit pedagogical backbone, so your proposal explicitly positions Revit BIM as a structured DT oriented strategy rather than a mere drafting or visualization tool. Second, many programs treat technical proficiency in isolation from user centred problem solving; your approach bridges this by anchoring Revit driven tasks, such as structural modelling, clash detection, and quantity take offs, within the DT stages of empathize, define, ideate, prototype, and test, so technical skills directly serve innovation and evidence based decision making. Third, existing BIM driven projects often remain discipline bound and fail to foster systematic collaboration; your design introduces shared BIM execution plans, multidisciplinary coordination, and empathy building tasks, turning Revit into a collaborative platform that mirrors professional practice. Fourth, current BIM education literature tends to measure outputs and less frequently addresses student motivation and self-regulated learning; by integrating the ARCS model and structured planning, monitoring, and evaluation tasks, your work fills this gap and supports affective and metacognitive development. Finally, in Colombian context institutions, curricula often lag global BIM industry standards; your Revit BIM DT strategy explicitly aligns with international workflows (clash detection, analytical models, quantity take offs, shared execution plans), thereby narrowing the gap between local academic training and global professional expectations.

In response to these gaps, your study establishes a clear and coherent set of objectives. The general objective is to strengthen Revit BIM as a didactic strategy that fosters Design Thinking in civil engineering students at Areandina University, enhancing their technical proficiency, collaborative skills, and innovative problem-solving capacity while aligning academic training with global industry standards. This repositions Revit from a passive modelling tool to an active, structured environment where BIM based learning integrates both technical industry expectations and the human centred, iterative logic of Design Thinking. The four specific objectives operationalize this intent: (1) technical proficiency develops mastery of Revit navigation, project setup, and parametric modelling of structural elements, applying industry aligned workflows to realistic civil infrastructure simulations; (2) DT integration guides students through all five stages using Revit BIM outputs, producing requirement matrices and iterative model refinements grounded in peer feedback and self-reflection; (3) collaboration and interdisciplinary skills are strengthened via shared BIM execution plans, multidisciplinary coordination, and explicit empathy building, preparing students for team based professional environments; and (4) motivation and self-regulation are promoted through ARCS informed tasks and reflective learning strategies that boost engagement, confidence, and autonomy. Collectively, these objectives create a coherent, learner centred Revit BIM DT framework that directly responds to the identified gaps in technical, collaborative, motivational, and curricular alignment dimensions.

II. *METHODOLOGY*

This finished project uses a design-based research (DBR) approach to enhance and refine Revit-BIM as a didactic strategy that fosters DT in Civil Engineering students at Areandina, combining iterative pilots, feedback cycles, and progressive scaling.

A. General Objective

To strengthen Revit-BIM as a didactic strategy that fosters Design Thinking (DT) in civil engineering students at Areandina University, enhancing their technical proficiency, collaborative skills, and innovative problem-solving capacity while aligning academic training with global industry standards.

Specific Objectives

1. Technical Proficiency

- Enable students to master Revit interface navigation, project setup, and parametric modeling of structural elements (beams, columns, slabs, foundations).
- Apply BIM workflows such as clash detection, analytical modeling, and quantity takeoffs to simulate real civil infrastructure projects.

2. Integration of Design Thinking

- Guide students through DT stages (empathize, define, ideate, prototype, test) using Revit-BIM to frame stakeholder needs, generate alternatives, and validate solutions.
- Produce traceable requirement matrices and iterative model refinements based on peer feedback and self-reflection.

3. Collaboration and Interdisciplinary Skills

- Strengthen teamwork through shared BIM execution plans, multidisciplinary coordination, and collaborative project development.
- Promote communication across disciplines and foster empathy for diverse stakeholder perspectives.

4. Motivation and Self-Regulation

- Incorporate ARCS motivational model (Attention, Relevance, Confidence, Satisfaction) into DT tasks to sustain engagement.
- Develop students' ability to plan, monitor, and evaluate their learning strategies, fostering autonomy and persistence.

5. Curricular Innovation and Sustainability

- Integrate BIM-based strategies into civil engineering curricula to cultivate adaptive, future-ready engineers.
- Emphasize sustainability awareness and digital transformation as core competencies for professional practice.

The methodology is grounded in motivation and self-regulation principles (goal setting, monitoring, strategic control) emphasized in [15] based on treatment of motivation and self-regulation for learning and instruction according to Fig. #2:

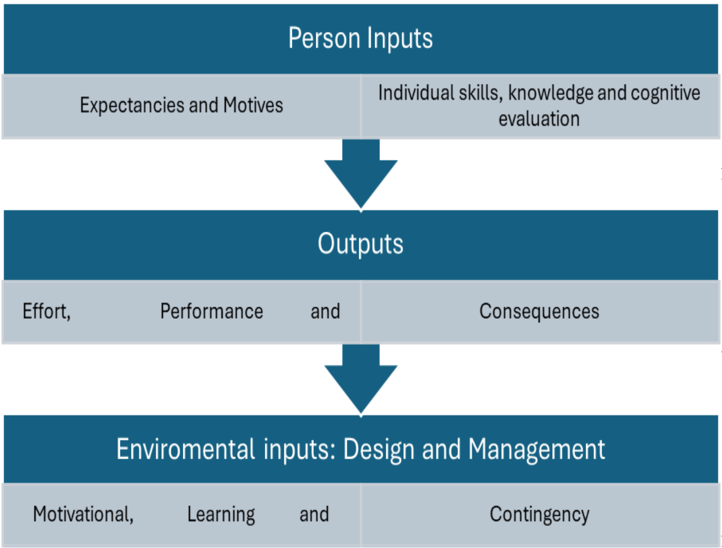

Fig. 2 A model of motivation based on [16].

The central assumption is that design thinking tasks (empathize–define–ideate–prototype–test) become more learnable when students regulate their effort, time, and strategies, and when instructional design intentionally supports motivation (e.g., authentic problems of local buildings, clear goals, usable feedback), regarding Fig. #3:

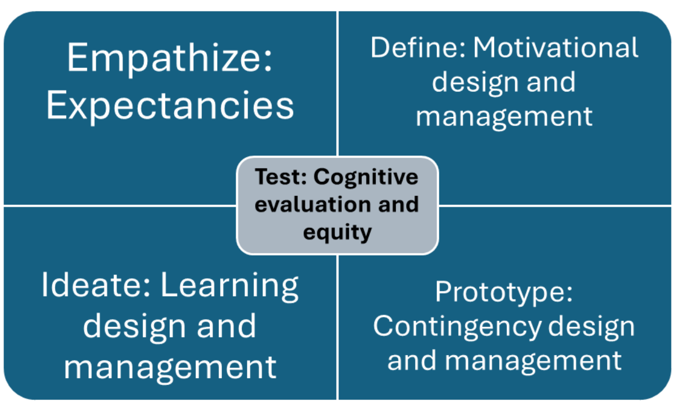

Fig. 3 Design Thinking Tasks coordinated with ARCS model.

A. Participants and context

The intervention targets 315 Civil Engineering students, organized into cohorts (e.g., by semester level) and subdivided into stable teams to support collaborative design thinking and peer-regulation. Each cohort completes the same core BIM learning sequence but with project complexity adjusted to prior knowledge (e.g., introductory modelling vs. interdisciplinary coordination).

To manage scale and equity of access, the strategy includes blended delivery (lab plus asynchronous micro-modules) and standard "BIM learning sprints" with explicit self-regulation checkpoints (plan–do–check–act) embedded into each task.

B. Didactical strategy (step-by-step)

Armed with a repertoire of these strategies, teachers and instructional students may use the systematic process described in the Fig. #3 to effectively meet the motivational needs of their students:

Step 1 (Empathize/Define): Teams analyze a real civil/infrastructure scenario and translate stakeholder needs into measurable design requirements and constraints (codes, constructability, safety). Self-regulation is operationalized through learning contracts, weekly goals, and criteria for success aligned with the task.

Step 2 (Ideate): Students generate multiple solution alternatives and document decision rationales; motivation is supported by autonomy (choice among alternatives) and relevance (industry-like constraints).

Step 3 (Prototype/Test in Revit-BIM): teams model, iterate, and validate solutions using parametric objects and coordination routines, using structured reflection prompts to monitor progress and adjust strategies across cycles of performance and self-reflection.

C. Data collection and instruments

Learning evidence is collected through: (a) Revit model artifacts and version histories (prototype iterations), (b) DT rubrics applied to problem framing and testing quality, and (c) self-regulation logs capturing forethought (planning), performance (monitoring), and self-reflection (evaluation). In addition, short motivation/self-efficacy questionnaires are applied at the start and end of each sprint to detect changes during the intervention.

Triangulation is achieved by combining product data (BIM deliverables), process data (logs, peer-feedback records), and perception data (surveys), enabling identification of which instructional supports most strongly relate to persistence and iteration quality.

D. Analysis plan

Quantitative analysis compares measures of motivation and self-regulation indicators across cohorts and across sprint cycles, while controlling for prior BIM exposure using baseline diagnostics for learning process. Qualitative analysis uses content coding of reflection logs and design rationales to identify self-regulatory strategies (e.g., help-seeking, time management, error diagnosis) that correlate with stronger prototype-test loops.

Design-thinking outcomes are inferred from rubric trends across iterations (e.g., improved requirement traceability, better testing evidence, fewer unresolved clashes), and results are fed back into the next DBR iteration (revise modules, supports, team structures).

E. Implementation resources and feasibility

Implementation requires a minimum computing baseline and a shared modeling protocol to avoid "tool friction" dominating learning time; prior BIM implementation studies note that computational resources and software selection influence feasibility and the learning experience [18]. The intervention therefore standardizes templates, naming conventions, and model exchange rules to reduce cognitive overhead and allow motivation to be directed toward design thinking rather than interface troubleshooting, [19].

Faculty development focuses on consistent coaching behaviors (feedback timing, rubric use, and scaffolding) so that students receive clear signals for self-monitoring and improvement, conditions according to [15] associate with effective instructional support for self-regulated learning shown in Table II:

TABLE II
DIDACTICAL SEQUENCE ALIGNED WITH DESIGN THINKING AND SRL

Phase	Design thinking activity	Revit-BIM learning task	SRL support (motivation/self-regulation)
1	Empathize/Define	Requirements plus constraints sheet linked to model scope	Weekly goals plus success criteria.
2	Ideate	Alternatives sketch plus massing concepts	Autonomy plus relevance to sustain motivation.
3	Prototype	Parametric modeling and documentation set	Monitoring checklist plus peer feedback.
4	Test	Coordination review plus issue list	Self-reflection log plus revision plan.

Table II describes how generating satisfaction creating natural consequences by providing students with opportunities to use newly acquired skills. In the absence of natural consequences, we may use positive consequences, such as verbal praise, real or symbolic awards. Important to ensure by maintaining consistent standards and matching outcomes to expectations for a metasystemic process, shown in Fig. #4:

Fig. 4 Metasystemic process.

And the Fig. #5 is shown an example of this metasystemic process:

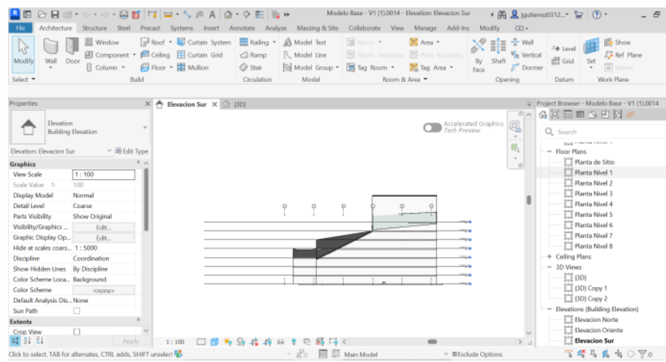

Fig. 5 Design using Revit-BIM in a local building

In Fig. #6 is shown a complete building:

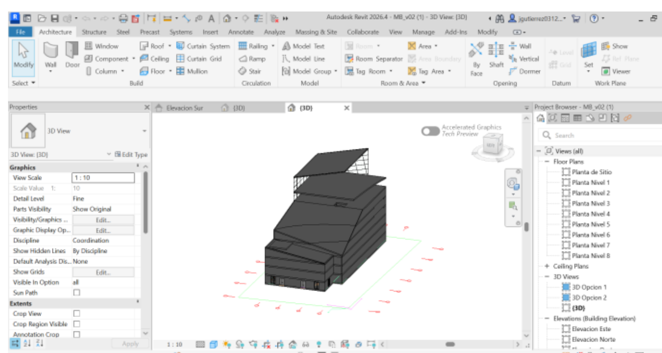

Fig. 6 Complete building using 3D view.

Conducting a student analysis requires rating the attitudes in each of the categories of that process can determine what motivational needs exist and therefore what motivational objectives should be set. The motivational design process, therefore, begins with considerations of the following characteristics:

1) Technical Proficiency

Students will master Revit interface navigation, project setup, and creation of structural elements like beams, columns, foundations, slabs, and reinforcement detailing. They will apply BIM workflows for analytical modeling, clash detection, and quantity takeoffs to simulate real civil infrastructure projects.

2) Design Thinking Integration

Participants will apply design thinking stages (empathize, define, ideate, prototype, test) using Revit to frame stakeholder needs, generate alternatives, and validate solutions via simulations. Objectives include producing traceable requirement matrices and iterative model refinements based on peer feedback and self-reflection logs.

3) BIM Collaboration Skills

Students will coordinate multidisciplinary models, export schedules, and generate construction documentation aligned with industry standards. They will demonstrate project coordination through shared BIM execution plans and 4D/5D simulations for civil projects like bridges or retaining walls.

Key learning objectives for the Revit-BIM as a didactical strategy on equipping civil engineering students at Areandina with parametric modeling skills integrated with design thinking principles, citing [20]. These objectives emphasize practical application to foster self-regulated learning through iterative prototyping and collaboration in Table III:

TABLE III

DIDACTICAL STRATEGY LEARNING OBJECTIVES

Topics	Objectives	Assessment
Basics	Interface mastery; model structural elements	Basic model submission
Design Thinking	Ideate/prototype with empathy-driven requirements	Iteration rubric
Advanced BIM	Clash detection; schedules/quantities	Coordination report
Collaboration	Multidisciplinary federation; documentation	Capstone project

In Table IV, we provide opportunities for matching students' motives and values with occasions for self-study, leadership, and cooperation for incresing familiarity by building on students' experiences.

TABLE IV
EVIDENCE AND EVALUATION

Evidence source	What it measures	When collected
BIM artifacts (models/exports)	Prototype quality and iteration	Every sprint.
Reflection logs	SRL phases: plan, monitor, reflect	Weekly.
Motivation/self-efficacy survey	Persistence and perceived competence	Pre/post each sprint.
Design thinking rubric	Problem framing, testing rigor, learning from feedback	Mid and end of project.

III. INSTRUCTIONAL DESIGN

The Revit-BIM course spans one academic semester (16 weeks), aligning with Areandina's civil engineering curriculum to accommodate 315 students across multiple sections without disrupting core coursework.

Weekly time commitment totals 12 hours: 4 hours of synchronous lab sessions for Revit modeling and design thinking workshops, plus 8 hours of asynchronous self-regulated tasks including prototyping iterations, self-reflection logs, and peer coordination.

A. Course Structure.

The 16-week duration follows a scaffolded progression: Weeks 1-4 build technical Revit foundations, Weeks 5-10 integrate design thinking cycles with BIM workflows, and Weeks 11-16 focus on capstone projects with 4D/5D simulations. This timeline ensures progressive mastery while allowing weekly checkpoints for motivation and self-regulation per [15] framework. Blended delivery minimizes scheduling conflicts, with labs utilizing university computer clusters during peak availability periods of Table V:

TABLE V
TIME BREAKDOWN AND WEEKLY TIME COMMITMENT

Activity	Hours/Week	Description
Synchronous Labs	4	Instructor-led Revit modeling, clash detection, team design thinking sessions
Asynchronous Tasks	6	Individual prototyping, self-regulation logs, requirement matrices
Collaboration/Reflection	2	Peer reviews, BIM coordination, iterative testing feedback
Total	**12**	Supports full-time student schedules

This structure balances intensive BIM practice with self-paced learning, fostering persistence through achievable weekly goals. Suggested pacing for the Revit-BIM course differentiates beginners from advanced civil engineering students at Areandina to optimize design thinking and self-regulation, using adaptive scaffolding based on baseline diagnostics administered in Week 1. Beginners receive extended tutorials and simplified projects, while advanced learners tackle complex integrations earlier, ensuring all reach capstone proficiency by Week 16.

B. *Beginner Pacing (Novice CAD Users)*

Beginners follow a deliberate 16-week ramp-up with heavier emphasis on fundamentals: Weeks 1-6 focus on Revit interface mastery, basic structural families, and simple 2D-to-3D conversions, with 6 hours/week on guided exercises. Weeks 7-12 introduce design thinking (empathize/define/ideate) via single-discipline models like isolated foundations, allocating extra reflection time for self-regulation.

C. *Advanced Pacing (Experienced Users)*

Advanced learners accelerate through a condensed path: Weeks 1-3 review tools via self-assessments, jumping to parametric customization and multi-story structures by Week 4. Design thinking phases start Week 5 with full cycles on interdisciplinary civil projects (e.g., bridges with MEP clashes), emphasizing 4D scheduling and optimization. Weeks 9-16 dedicate time to leadership roles in team capstones, mentoring peers to reinforce motivation and regulation skills.

D. *Differentiation Features*

TABLE VI

PACING COMPARISON

Week Range	Beginners (Focus)	Advanced (Focus)
1-4	Interface, basic elements	Review + families/customization
5-10	Intro design thinking, simple prototypes	Full cycles, 4D/5D sims
11-16	Coordination intro, capstone	Leadership, complex infra
Weekly Add-Ons	Extra labs (2h), tutorials	Mentoring (2h), extensions

Diagnostic formative assessment and progress logs enable dynamic shifts between tracks, promoting equitable outcomes across 315 students.

III. FINDINGS AND DISCUSSION

The survey applied to civil engineering students (315) in 2025-2 (second semester of 16 weeks) at Areandina University provides a comprehensive evaluation of the Revit-BIM and Design Thinking integration as a didactic strategy. Overall, the results reflect high levels of satisfaction across key dimensions, learning outcomes, methodology, instructional design, didactical strategies, and evaluation, demonstrating the effectiveness of this innovative approach in fostering technical competencies, collaborative skills, and motivational engagement. Table VII describes the results of Likert survey applied:

TABLE VII
SURVEY APPLIED TO 315 STUDENTS IN 2025-2

Category	Item Evaluated	Mean (1-5)	% Satisfied (4-5)	Qualitative Observations
Learning Outcomes	Development of technical competencies (parametric modeling, clash detection, simulations)	4.3	87%	Students highlight improvements in spatial reasoning and sustainability awareness.
	Integration of Design Thinking in real projects	4.1	82%	Empathy and ideation were valued, though some reported initial difficulty with Revit.
Methodology	Use of collaborative projects and teamwork	4.4	89%	Group dynamics fostered motivation and self-regulation.
	Sequence of phases (Empathize, Ideate, Prototype, Test)	4.2	85%	The structure was clear, though some requested more time in the prototyping phase.
Instructional Design	Integration of ARCS (Attention, Relevance, Confidence, Satisfaction)	4.0	78%	Motivation increased, but students suggested stronger individualized feedback.
	Clarity of objectives and rubrics	4.3	86%	Rubrics facilitated self-assessment and requirement traceability.
Didactical Strategies	Introductory workshops and hybrid modules	4.2	84%	The hybrid format allowed flexibility, though some reported technical limitations.
	Capstone projects shared in BIM execution plan	4.5	91%	Final projects were highly valued for their practical applicability.
Evaluation	Use of Design Thinking rubrics and self-reflection	4.1	80%	Self-assessment strengthened perceptions of self-efficacy.
	Motivation surveys and self-regulation logs	3.9	74%	Some students found the questionnaires repetitive, though useful for tracking progress.

At this overall summary, general satisfaction level was 4.25/5; and percentage of satisfied students (4-5) was 85%. The strengths were collaborative projects, integration of Design Thinking, practical applicability in infrastructure. And areas for improvement, a greater support during initial Revit-BIM phases, optimization of technical resources, more personalized feedback.

Cronbach's Alpha was of 81%, good reliability across 5 categories. The consistency of high averages (most items above 4.0) and tight satisfaction range suggest the items are homogeneous and measure related aspects of instructional quality. Qualitative observations were also aligned as students consistently mention motivation, teamwork, clarity, and applicability, reinforcing internal coherence, demonstrating solid internal consistency. Students' responses across categories are coherent and mutually reinforcing, meaning the instrument reliably captures perceptions of the Revit-BIM + Design Thinking strategy.

Then, the table VIII shows the Likert survey applied to 288 students who were not exposed to Revit-BIM as a Didactic Strategy:

TABLE VIII

SURVEY APPLIED TO 288 STUDENTS WITHOUT REVIT-BIM STRATEGY

Category	Item Evaluated	Mean (1-5)	% Satisfied (4-5)	Qualitative Observations
Learning Outcomes	Development of technical competencies (parametric modeling, clash detection, simulations)	3.9	74%	Students noted progress in spatial reasoning, but some struggled with advanced workflows.
	Integration of Design Thinking in real projects	3.7	69%	Empathy and ideation were appreciated, though several students felt the process was rushed.
Methodology	Use of collaborative projects and teamwork	4.0	77%	Teamwork was generally positive, but uneven skill levels created challenges in group dynamics.
	Sequence of phases (Empathize, Ideate, Prototype, Test)	3.8	72%	The sequence was clear, but students requested more guidance during the prototyping stage.
Instructional Design	Integration of ARCS (Attention, Relevance, Confidence, Satisfaction)	3.6	65%	Motivation improved moderately; however, feedback was perceived as inconsistent across cohorts.
	Clarity of objectives and rubrics	3.9	73%	Rubrics were useful, but some students found criteria too rigid for creative exploration.
Didactical Strategies	Introductory workshops and hybrid modules	3.8	70%	The hybrid format offered flexibility, but technical limitations reduced accessibility for some.
	Capstone projects shared in BIM execution plan	4.1	79%	Final projects were valued, though students suggested more industry-relevant case studies.
Evaluation	Use of Design Thinking rubrics and self-reflection	3.7	68%	Self-assessment promoted awareness, but some students felt reflection activities were repetitive.
	Motivation surveys and self-regulation logs	3.5	62%	Questionnaires were seen as useful but burdensome, with limited impact on perceived progress.

From this quantitative overview, the overall mean (1–5 scale) was 3.8, indicating a generally positive perception, though not outstanding. The average satisfaction (% with scores 4–5) was 70.9%, roughly 7 out of 10 students expressed satisfaction, leaving room for improvement.

V. CONCLUSIONS

Revit-BIM as a teaching strategy to promote DT among civil engineering students at the Universidad Areandina is a proposal for implementation in nine disciplinary academic subjects with 315 students as a pilot project by integrating parametric modeling with self-regulated learning principles from [15]. The 16-week blended didactical strategy, with differentiated pacing for beginners and advanced students, addresses implementation challenges like steep learning curves through scaffolded phases, weekly 12-hour commitments, and motivational support such as goal setting and reflection logs.

A. Key Outcomes

The methodology yields measurable gains in technical proficiency (4D simulations), design thinking competencies (iterative prototyping, stakeholder empathy), and self-regulation (planning/monitoring/reflection), preparing graduates for BIM-driven civil projects of academic subjects [21]. Scalable across cohorts via cloud resources and peer mentoring, it overcomes resource constraints while aligning with industry standards.

B. Implications

This proposal offers a replicable framework for Latin American institutions, balancing innovation with feasibility amid hardware limitations. Future iterations will incorporate longitudinal tracking of alumni BIM adoption to validate sustained impact on professional practice and sustainable infrastructure delivery.

According to [22], Revit-BIM emerges as a powerful didactic strategy that directly operationalizes DT's iterative cycle, empathize, define, ideate, prototype, test, within Areandina's civil engineering curriculum for 315 students. By embedding parametric modeling workflows into self-regulated learning phases (planning, monitoring, reflection), the strategy transforms abstract design thinking principles into tangible BIM artifacts, where stakeholder needs become traceable model parameters and prototypes evolve through clash detection and simulation feedback.

This association cultivates authentic design competencies, as students regulate their motivation toward empathetic problem-framing (Weeks 1-6) and rigorous testing (Weeks 11-16), yielding proficient graduates in collaborative, data-driven infrastructure design, [23]. The 16-week scaffolded pacing ensures beginners master fundamentals while advanced learners lead complex integrations, demonstrating scalable synergy between BIM tools and DT methodologies.

C. Relationship between Revit-BIM and DT.

Defining Revit-BIM as identifying one method that will best provide the conditions under DT goals will most likely be attained. Citing [24], for an instructional theory to be effective, it must either build on or be compatible with existing learning theory. In other words, DT specifies the link between what is learned and the conditions under which Revit-BIM learning occurs. What should also be noted about Revit-BIM method is that it involves intentional learning goals. That is, learning will occur whenever conditions are ripe, and in fact, learning goes on all the time. Instructions for Revit-BIM designs, refer to the deliberate arrangement of learning conditions to promote the attainment of some intended goal of DT, as depicted in Fig. #7:

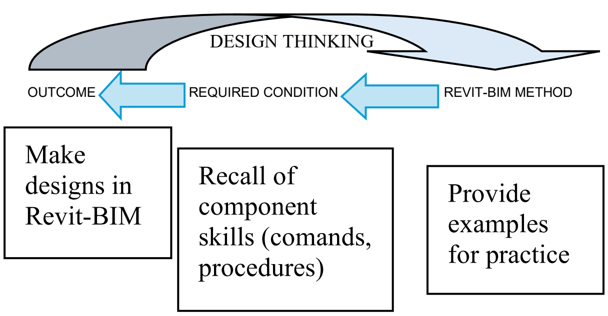

Fig. 7 Relationship between Revit-BIM and DT.

Therefore, the purpose of Revit-BIM as a didactical strategy is to be prescriptive, to provide principles by which teachers can ensure learning. Because prescription is probabilistic in nature, rather than deterministic, [25] prefers to use the term *design-oriented* that offers methods of instruction for different situations that increase the probability that desired learning outcomes will occur. The goal of any Revit-BIM-based didactical strategy is to attain the highest possible probability of the desire results to acquire DT proficiency, citing [26].

Finally, regarding [27] argues that teachers must consider four components for applying relationship between Revit-BIM and DT in the subjects for civil engineering program:

- The student
- The learning task (including desired learning aoutcomes)
- The learning environment (learning conditions and instructional methods from Revit-BIM)
- The frame of reference (or the context in which learning is to occur, for instance, suitable and well-equipped laboratories with all programs of Autodesk).

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