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The Rex Project – An Activity for Teaching the Evolution of Design Representation in Construction Education

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Building Information Modeling (BIM) has transformed the architecture, engineering, and construction (AEC) industry, creating new demands for integrative and experiential learning approaches in higher education. This paper presents an innovative classroom activity — the “Rex Project” — designed to introduce undergraduate construction management students to the historical evolution of design representation, from primitive methods to Building Information Modeling. Using tangible materials such as chalk, paper, Play-Doh, and LEGO, students simulate different eras of design technology, fostering critical reflection on how representative methods shape professional practice. Using project-based learning principles, the activity promotes collaboration, engagement, and conceptual understanding of BIM as an information-rich process rather than a software tool. Quantitative and qualitative results confirm that students grasped the progression of design technologies and their practical implications. The study suggests that experiential, team-based learning enhances conceptual understanding and prepares students for the construction industry's digital transformation.
Keywords: Construction, Education, BIM

Introduction

The architecture, engineering, and construction (AEC) industry has undergone a significant digital transformation with the rise of Building Information Modeling (BIM). BIM is not only a 3D modeling tool—it is a comprehensive process that integrates geometry, data, and workflows across the entire building lifecycle (Eastman et al., 2011). This shift has redefined professional practice and, consequently, the way construction and design education must prepare future professionals.
As BIM adoption grows, universities face the challenge of aligning curricula with industry demands by equipping students with both technical skills and collaborative competencies (Sacks & Pikas, 2013). Effective BIM education must go beyond software training, emphasizing teamwork, problem-solving, and interdisciplinary coordination. To address these goals, pedagogical strategies such as project-based learning (PBL) have proven effective in simulating real-world professional environments and enhancing student engagement (Linares et al., 2025).

This paper explores an innovative teaching method for introducing BIM concepts to undergraduate students, focusing on experiential and collaborative approaches. It presents a classroom activity designed to connect the evolution of design representation—from manual drafting to digital modeling—helping students understand how BIM fits within this continuum and supports modern construction management practices.

Literature Review

BIM Teaching

The widespread adoption of BIM in industry has necessitated its integration into higher education. Succar, Sher, and Williams (2013) identify eight domains of BIM competence, ranging from managerial and operational to technical and research skills. These competencies can be acquired through formal education, on-the-job training, or professional development. Peterson et al. (2011) demonstrate that BIM can serve as both a teaching goal and a pedagogical tool, especially in construction management courses where simulations mirror real-world scenarios.

Universities have increasingly adopted BIM to bridge the gap between academic theory and professional practice. Abbas, Din, and Farooqui (2016) highlight its adaptability across in-person and online contexts, while Müller et al. (2016, 2021) describe institutional efforts to build BIM culture through curricular reform and digital delivery. More recent studies suggest that project-based approaches enhance student engagement by situating BIM in real or industry-provided projects (Jin et al., 2018; Linares et al., 2025). Challenges remain such as software interoperability and faculty training remain barriers to widespread adoption (Correa et al., 2025).

Learning Styles and Teaching Methods

Effective BIM education requires alignment with diverse learning styles and pedagogical strategies. The Present-Practice-Produce (PPP) model, derived from cognitive skill acquisition research (Anderson, 1982), provides a framework for student learning. Here, instructors first introduce content, then guide structured practice, before students engage in autonomous project development. This model is well suited to BIM teaching, as it encourages application through practical modeling tasks.

Different learning styles—visual, auditory, and kinesthetic—should be considered (Vincent & Ross, 2001). Visual learners benefit from BIM's graphic and color-coded interfaces, auditory learners gain from instructor explanations and discussions, while kinesthetic learners thrive in hands-on modeling exercises. Project-based learning (PBL) enables students to "learn by doing" through real world projects (Krajcik & Blumenfeld, 2006; Kokotsaki, Menzies, & Wiggins, 2016). Recent work emphasizes hybrid approaches that combine student identified projects with industry provided tasks to balance autonomy and connection to the real world (Linares et al., 2025). Moreover, team based learning (TBL) promotes collaborative problem solving, an essential skill in BIM's multidisciplinary context (Michaelsen, Knight, & Fink, 2004). When integrated with BIM, TBL and PBL approaches enhance student engagement and professional readiness.

History of Drafting and Design in Construction

Early design practices relied on physical markers like stakes and strings, producing impermanent, site-based layouts. Medieval builders used simple tools—L-squares, strings, levels—with minimal graphic representation (Ousterhout, 1999). Parchment was reserved for sacred texts, and designs were sometimes carved onto stones or bricks (Kolarevic, 2003). Scaled models functioned as early maquettes.

The advent of paper, ink, and instruments revolutionized design, enabling standardized, transportable drawings. Renaissance innovations like perspective and orthographic projection improved communication, while twentieth-century drafting required technical precision (Lawson, 2002). Traditional tools—rulers, compasses, clay models—remained in use until the 1980s (Penttillä, 2006).

Hand-drafting major works, such as the Guggenheim Bilbao, would have been impractical (Kolarevic, 2003).

2D CAD digitized drafting improved speed and accuracy though conceptually mirroring manual methods. From Sutherland's Sketchpad (1963) to the 1990s, CAD evolved into "electronic drafting boards," enhancing productivity and reducing documentation errors (Ayres, 2007; Azuma et al., 2007).

3D CAD introduced volumetric modeling, enhancing spatial understanding but still lacking material data. It enabled more realistic simulations and greater geometric exploration (Ayres, 2007). Though not fully parametric, 3D CAD marked a key step toward digital prototyping (Penttillä, 2006). BIM integrates data-rich, parametric components combining geometry, materials, and cost information. It supports visualization, quantity takeoffs, and lifecycle management. Eastman et al. (2008) describe BIM as spanning a building's entire lifecycle, while Lee, Sacks, and Eastman (2006) emphasize "building object behavior," where elements carry performance data.

Collectively, this body of work shows that BIM is more than a technological advancement, it has become a core instructional component in construction engineering and management education. Previous studies emphasize that construction curricula must prepare students with industry-aligned competencies such as technical proficiency, interdisciplinary coordination, and effective problem-solving and decision-making skills (Succar et al., 2013; Peterson et al., 2011). When BIM is combined with instructional methods like project-based learning and team-based learning, it supports experiential learning environments that mirror professional practice and promote workforce readiness (Krajcik & Blumenfeld, 2006; Michaelsen et al., 2004; Jin et al., 2018). In addition, situating BIM within the historical progression from manual drafting to data-rich digital models provides important educational context, helping students understand how technological advances have shaped construction practices and decision-making over time (Penttillä, 2006; Eastman et al., 2008). Building on this literature, the present study considers BIM both as a learning outcome and as an instructional tool to support competency development in contemporary construction education programs.

Methodology

Activity Overview

This paper describes the case-study for a classroom activity based on a group dynamic and a follow up assignment. The dynamic is described below, and the follow-up assignment was meant to reinforce and review the topics, however, some data was able to be collected from the assignment and researchers were able to analyze the effectiveness of the activity.

This activity was designed to promote experiential learning and collaboration regarding the evolution of construction design methods. Its goal was to illustrate the curriculum's progression—from manual drafting to 2D CAD, and finally BIM/VDC—helping students contextualize their learning path. The exercise encouraged teamwork and critical reflection on how technology shapes design representation. The primary learning objective was to "understand the importance, use, and main characteristics of each design method through history."

This activity caters to the three learning styles: Auditory students are able to listen and discuss during the presentation, visual students are catered through the presentation and mind map visuals while kinesthetic students can create and model though the presented tools. Though in small scale, this is also a demonstration of project-based learning, since students are allowed to create a small project and work in teams to produce their design and presentation.

The activity divides students into "companies," each assigned a material set representing a historical design era: Team 1 (Chalk/Chalkboard), Team 2 (Pen/Paper), Team 3 (MS Paint), Team 4 (Play-Doh), and Team 5 (Legos). Tasked with designing a doghouse for a client named "Rex," teams have 15 minutes to develop a proposal and prepare a competitive presentation defending their method's superiority. The session concludes with a peer voting exercise, excluding self-selection, to encourage critical comparison of the different tools and outcomes.

Conceptual Framework and Theoretical Linkages

Through this comparative framework, students gain a tangible understanding of how design representation evolved from analog to digital paradigms, culminating in information-rich modeling systems. After the presentations, the instructor introduces a mind map showing how each group's material corresponds to a stage in the historical evolution of design technologies. The Design era and their analog materials are shown in Table 1.

Design era	**Materials Given**	**Common characteristics**
Pre-paper design	Chalk, chalkboard, and string	Non-rigid drawing, fragility of material, freedom of form, ease of change
Paper design era	Pen and paper	Ease of transportation, difficult to make change, availability
2D CAD	MS Paint	Ease of sending - storing, ease of change, 2D only.
3D CAD	Play Doh	Good visualization. freedom of form, skills required
BIM	Lego	Good visualization, form rigidity, ease of estimating

Table 1 - Design era and analog materials for the activity.

Assessment and Follow-Up Activity

To reinforce learning, a follow-up assignment is administered via Canvas. The online exercise includes multiple components:

- Matching exercise: Students connect used materials to the historical design era they represent;
- Multiple-choice questions: These assess comprehension of the defining characteristics of each design phase, such as modifiability, data integration, and visualization capacity;
- Short essay responses: Students explain how each material reflects its corresponding era;
- Reflective questions: Students rate their familiarity and confidence with design concepts and collaborative work, as well as provide qualitative feedback on the activity.

The Canvas activity provides both descriptive quantitative data—useful for evaluating comprehension trends—and qualitative insights—useful for understanding student perceptions and conceptual connections. While multiple-choice questions allow for efficient data collection and analysis, the inclusion of short essay responses encourages deeper reflection and qualitative engagement with course content.

This activity was used by two different classes in the major of construction management in two different universities, the first a Construction drawing class with 40 students on average of Freshman or Sophomore levels. The second is an advanced construction computer application course with 9 students at the Junior Level.

Expected Outcomes

This methodology seeks to bridge theoretical and practical learning by translating abstract historical concepts into hands-on, creative experiences. By simulating design eras through tangible materials, students can better grasp the progression of representational tools, their limitations, and their influence on professional practice. Moreover, the activity promotes collaboration, critical thinking, and active learning—key pedagogical principles in construction and architectural education.

Results

Students created their designs and presentations in class, and in the following week students answered the follow-up activity. Some of the designs created in class are shown in Figure 1., and some snapshots of their presentations containing some arguments are shown in Figure 2.

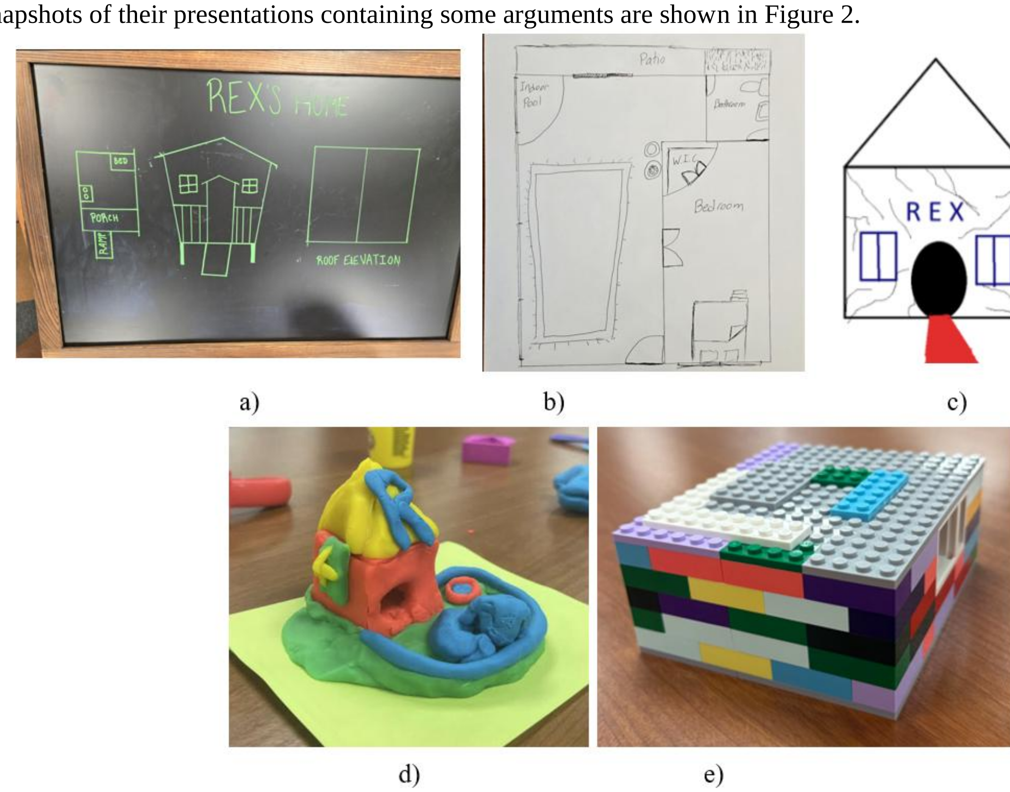

Figure 1. Designs created - a) Chalk; b)Pen and paper; c) MS Paint; d) Play-Doh; e) Lego

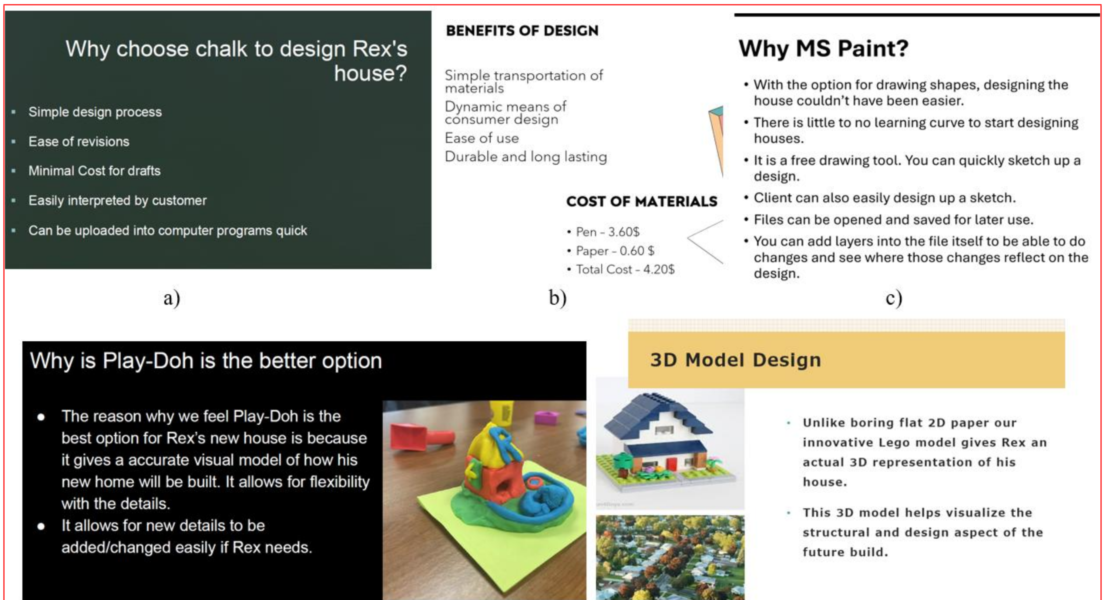

Figure 2. Presentations - a) Chalk; b) Pen and paper; c) MS Paint; d) Play-Doh; e) Lego

Students' Knowledge Gain through the REX Activity

The descriptive quantitative analysis (Figure 3) of this research presents that most participants were able to correctly identify the main characteristics of each design era, indicating that the REX activity effectively supported knowledge acquisition and concept retention.

For the Primitive methods, 91% of students correctly selected the use of geometric primitives such as lines and arcs, showing that they understood how early designs relied on basic forms. For the Paper era, 82% of students recognized that geometric primitives were still used and 62% identified ease of transportation as a key improvement, reflecting that they grasped how the invention of paper made drawings easier to reproduce and share. In the 2D CAD era, nearly all students selected the correct characteristics, with 100% recognizing ease of change and 94% identifying ease of transfer, showing that they clearly understood how computer drawing increased flexibility and efficiency. The results for the 3D CAD era were equally strong, with 100% acknowledging 3D visibility and 97% recognizing ease of change, which indicates that students could distinguish how digital modeling improved spatial understanding. Finally, in the BIM era, 100% of respondents identified information models as the defining feature, while over 90% recognized ease of storage, extraction of quantities, and 3D visibility. This can be seen in the graphics shown on Figure 3.

These findings demonstrate that the REX activity made the learning process more intuitive by linking each era's technology to tangible materials, helping students better visualize the progression from simple sketches to intelligent, data-rich digital models

Figure 3. Average answers to the characteristics of each method question.

Students' Understanding of the Realism of Materials

The results show that most students were able to clearly connect the materials used in the REX activity with the design eras they represented. When analyzing how students related the materials used in the REX activity to the design eras they represented, the results showed that most participants were able to clearly connect each tool with its corresponding design period. This can be seen in the graphics shown on Figure 4.

Student comprehension of the material analogies was consistently high. 89% grasped the temporary, low-precision nature of chalk (Primitive methods), while 92% recognized the permanence and manual requirements of pen and paper (Paper era). Regarding digital tools, 89% agreed MS Paint effectively demonstrated 2D CAD concepts. Similarly, 92% viewed Play-Doh as a realistic representation of 3D CAD's volumetric geometry lacking embedded data. Finally, 92% linked Lego to BIM, recognizing how discrete components connect and carry data. Overall, results confirm students perceived these tools as effective for understanding the evolution from basic sketches to intelligent, data-driven models.

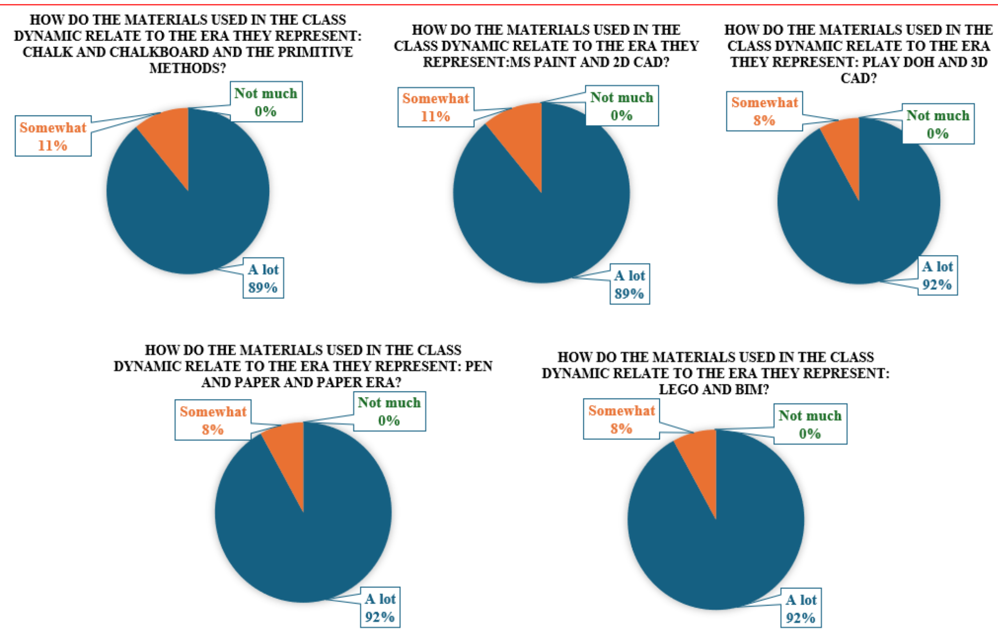

Figure 4. Students' Understanding of the Realism of Materials

Evaluation

Regarding subject familiarity, 67% of students reported little to no prior knowledge, and 52% noted only slight or moderate familiarity with specific concepts. This confirms REX's value as an introductory foundation rather than a reinforcement tool. Although software confidence was low-to-moderate, underscoring the need for scaffolding, 69% rated their ability to connect theory to practice as "good" or "very good." Teamwork ratings were similarly high, with 69% reporting "very good" or "excellent" skills. Overall, the results demonstrate that REX effectively supports engagement, collaboration, and practical application despite limited initial technical proficiency. This can be seen in the graphics shown on Figure 5.

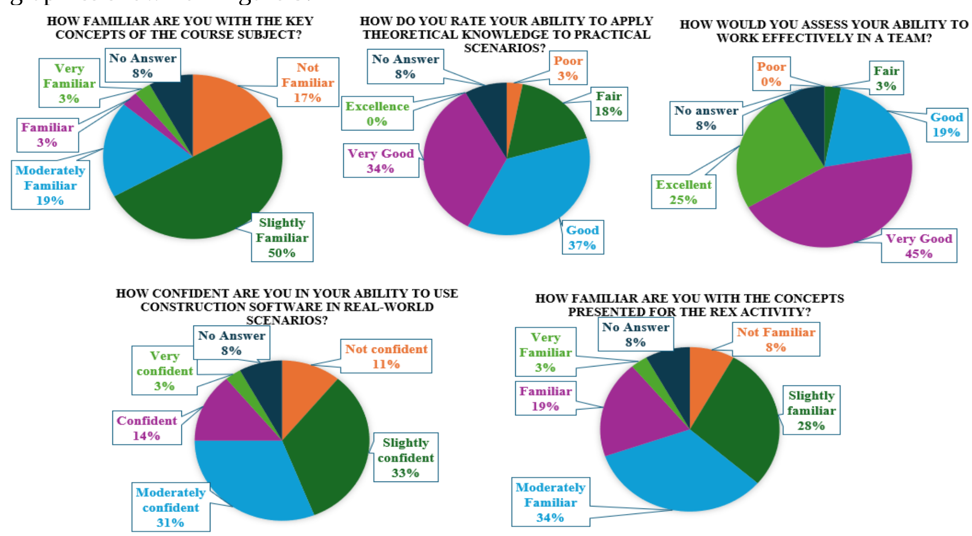

Figure 5. Students self-assessment.

Discussion

The REX activity provided a hands-on experience that clarified the evolution of construction design. This yielded valuable insights into how experiential learning fosters understanding of historical and current industry standards. Survey data indicated positive student reception and strong knowledge retention. While course-specific, the results suggest the activity is an engaging and beneficial teaching tool.

Future works

The authors plan to continue the REX activity and train other educators through future workshops. Longitudinal assessments will be conducted to track the activity’s impact on students' professional lives. Future iterations will also incorporate construction management concepts such as estimating, coordination, constructability, and sequencing.

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