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VIRTUAL REALITY AND EXPERIENTIAL LEARNING: A “TEACHING SITE” TOO (RE)INTEGRATE CONSTRUCTION AND DESIGN INTO ARCHITECTURE EDUCATION

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ABSTRACT
This article discusses how architecture education can benefit from a virtual reality “didactic construction site” to integrate theory and practice in construction education. Based on educational theories (Dewey, Kolb, Freire, and Schön), the text analyzes the recurring gap in technical learning, often dissociated from design disciplines. A prototype of a virtual construction site developed in Unity is presented, with guided and free interactions that allow students to experience construction procedures and, simultaneously, relate them to design decisions. The research was applied in an optional course with students from different semesters of an architecture course. Results indicate greater engagement, critical reflection, and practical understanding of the construction stages, expanding student autonomy and the correlation between design and execution. The potential contributions to the training of more complete professionals, technical challenges (such as cyber disease and infrastructure), and possibilities for expansion beyond the field of architecture are discussed, signaling paths for other educational areas interested in immersive practices and active teaching methodologies.

Keywords: Education. Virtual Reality. Construction Education. Experiential Learning. Active Methodologies.

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INTRODUCTION

Civil construction, although a fundamental dimension in the work of architects and engineers, has remained in a secondary position in many Architecture and Urban Planning curricula (LEITE, 2005; SANTOS NETO, 2019). In general, it is found that design disciplines receive greater attention, not only in terms of workload but also in terms of academic prestige, while construction education tends to be limited to excessively theoretical or fragmented approaches. This curricular imbalance makes it difficult to train professionals capable of articulating, in a solid manner, the conceptual dimension of the project with the actual execution procedures on the construction site.

Broadly speaking, construction disciplines are often presented to students in traditional lecture formats, focusing on the transmission of concepts and standards, but without providing the practical experience necessary to consolidate this knowledge. This contrast is accentuated when we consider that the very nature of construction involves the manipulation of materials, execution processes, and decision-making “in action”, requiring skills that go beyond theoretical mastery. In many contexts, students have difficulty relating what they learn in the classroom to real situations, losing sight of the concreteness and materiality of what they project. At the same time, the rare visits to construction sites — when feasible — do not guarantee the continuous rhythm of observation and practical learning, as they depend on external agendas, financial resources, safety protocols, and specific phases of the work. In more advanced cases, some institutions have physical “experimental construction sites”; however, they often face high maintenance costs and scale limitations. This scenario contrasts with recurring discussions in the educational literature about active methodologies and concrete experiences in the teaching-learning process. Dewey (1976) already highlighted the importance of student interaction with real or simulated problems to promote deep and meaningful understanding, while Freire (1979) defended the role of the subject as a protagonist in the construction of knowledge. Kolb (2015), in turn, presented the concept of experiential learning through a cycle that begins with concrete experience, goes through reflection and conceptualization, and then reaches active experimentation — configuring a cyclical process that enriches the internalization of content. In the context of professional courses, such as Architecture, Schön (2000) argues that reflective reasoning must occur simultaneously with action, which requires more immersive pedagogical practices than the simple transmission of theory.

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This is where virtual reality (VR) emerges as a promising resource, as it can create immersive environments on a real scale, allowing students to experience — albeit virtually — different stages of the construction site. This technology offers a safe space for experimentation, allows the repetition of construction stages without additional material costs, and reduces risks associated with the physical construction site. At the same time, interactivity motivates students to actively engage, creating a process of practical reflection on each executive choice. This dynamic is in line with the precepts of Dewey, Freire, Kolb, and Schön, helping to overcome the disparity between design and construction.

Given this, this article focuses on presenting and discussing the implementation of a “didactic construction site” in Virtual Reality, designed to facilitate practical construction learning in synergy with design teaching. The proposal aims not only to show preliminary results of engagement and practical understanding but also to point out the technical challenges (hardware, software, cybersickness, and logistics) and the opportunities for application in other fields that wish to integrate theory and practice through active methodologies.

THEORETICAL FOUNDATIONS AND EDUCATIONAL CONTEXT

EXPERIENTIAL LEARNING AND ACTIVE METHODOLOGIES

The consolidation of active methodologies in the educational field is supported by authors such as Dewey (1976), who emphasizes experience as the main source of knowledge; Kolb (2015), who describes the experiential learning cycle (concrete experience, reflective observation, abstract conceptualization, and active experimentation); and Freire (1979), for whom the student should be the subject of learning in a dialogical and emancipatory process. In parallel, Schön (2000) highlights the need for reflective practices, especially in professional fields such as Architecture, in which “know-how” and “thinking while doing” are crucial.

In construction disciplines, theoretical fragmentation contrasts with “in-the-moment” learning on the construction site. Therefore, a virtual environment that simulates this “act” and encourages decision-making (and possible mistakes) can catalyze student involvement and generate reflections on the materiality of the process. Architectural project.

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THE GAP IN EDUCATION IN CONSTRUCTION IN ARCHITECTURE

Traditionally, Architecture courses prioritize design disciplines, giving them more workload and prestige, while disciplines related to construction become secondary and excessively theoretical (LEITE, 2005). This model hinders the practical understanding of construction systems, reducing the technical repertoire of graduates. At the national level, specific initiatives such as experimental construction sites or technical visits are observed, but for various reasons — costs, logistics, safety, availability of work — they end up being insufficient or sporadic.

Because of this, the virtualization of these experiences emerges as a promising alternative. Although it does not replace the full experience of a real construction site, VR can provide a controlled, repeatable and safe environment, in which the student directly participates in the “virtual execution” of the elements of a building.

VIRTUAL REALITY AND EDUCATION

In the educational field, VR is often associated with benefits such as greater knowledge retention, engagement, and spatial understanding (CEYLAN, 2020). In constructivist approaches, the creation of risk-free learning environments is valued, in which students can make mistakes, learn from them, and reconstruct their understanding. These characteristics make VR potentially aligned with active learning theories, as advocated by Freire (1979) and Dewey (1976), who criticize the banking model of teaching and propose a more direct relationship between the learner and the object of study.

DEVELOPMENT OF THE EDUCATIONAL CONSTRUCTION SITE IN VR

PEDAGOGICAL PLANNING

The concept of the “educational construction site” in VR was designed to promote:

- integration with the project: each construction simulation (foundation, pillars, walls, roof, etc.) is related to design decisions, encouraging the student to understand their practical implications;
- two modes of interaction: the guided mode, which presents step-by-step tutorials of the construction stages, providing a basis for those who have no experience in construction; and the free mode, where the student designs a small shelter (or other program) and executes it on the virtual construction site, combining creativity and technical application.

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TOOLS AND VIRTUAL ENVIRONMENT

The prototype was developed in Unity software, integrating specific packages for VR (XR Interaction Toolkit). To access it, students use the Oculus Quest 2 device, which allows tracking of head and hand movements, offering a sense of presence. In addition, typical construction tools (shovel, tape measure, bucket, levels, etc.) were modeled and interactions were created that simulate digging, pouring concrete, erecting walls, installing steel frames, and so on.

To maintain educational coherence, each virtual object exhibits behaviors similar to those in the real world (such as gravity and the need for alignment), but in a simplified way, in order to avoid generating cognitive overload (Sweller, 1988). Furthermore, the choice to prioritize basic construction systems (reinforced concrete and masonry/dry sealing) was made with a view to conceptual clarity for beginners.

APPLICATION IN AN ELECTIVE DISCIPLINE

An experimental optional discipline was offered to 10 students from different semesters of Architecture at a public university (Figure 1). The sessions were organized weekly, with the first focused on familiarization with the VR equipment and introductory applications. The group then participated in construction tutorials (landmarking, foundation, slab and pillars, walls, and alternative systems), and then developed a small project — an “emergency shelter” — in free mode (Figure 2).

Figure 1: Students during the prototype usage session

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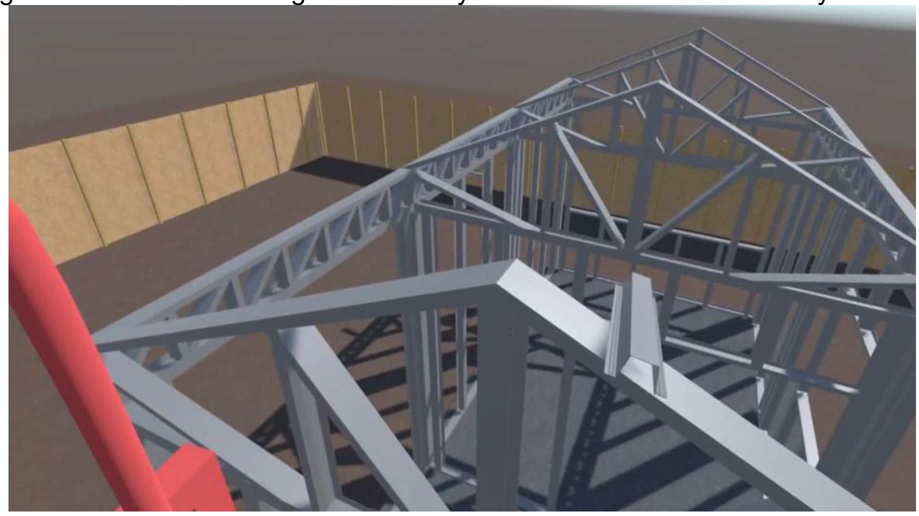
Figure 2: Screenshot during the assembly of the steel frame structure by a student



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RESULTS AND DISCUSSION

REFLECTIONS ON LEARNING: AUTONOMY AND ENGAGEMENT

By Freirean principles, student autonomy stood out when the free mode was used. Of the 10 participants, 100% reported having made adjustments to the project during the virtual execution, demonstrating reflection "in action" (SCHÖN, 2000). One of them highlighted: "I realized that the window I designed in the plan would be too low and would hinder the flow; I readjusted the height and learned to think better about these constructive aspects".

The level of engagement observed among students reflects the principles of experiential learning approaches, according to which direct involvement in an activity favors cycles of reflection, conceptualization, and re-experimentation, intensifying motivation and the sense of authorship (KOLB, 2015). In this sense, the constructive simulation in virtual reality works as an "experience device", generating conditions close to real experience, but in a safe and iterative environment. According to the questionnaires, 70% of the students rated the learning as "Yes, very" relevant to their understanding of construction, demonstrating greater involvement compared to strictly theoretical disciplines, according to their statements.

DESIGN-CONSTRUCTION INTEGRATION: OVERCOMING FRAGMENTATION

The pedagogical proposal of using the virtual construction site as an extension of the design studio helps to mitigate the usual dichotomy, since, at the same time as they plan, the students verify the feasibility of ideas and refine solutions. This is in line with the

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idea of “experiential learning” because instead of thinking of the project only as a drawing, the student anticipates its execution.

For some, the simulation of foundations and slabs raised questions about column modulation, overloading on slabs and the amount of reinforcement. Although the structural decisions were not calculated, this “almost real” exercise reinforced the value of a more integrated and practical basis.

CHALLENGES: CYBERSICKNESS, INFRASTRUCTURE, AND EDUCATIONAL CONTEXT

Despite the benefits, there were reports of motion sickness in 50% of students, especially in the first sessions. Given this, the “teleportation” function made it possible to reduce symptoms, corroborating previous studies on VR and cybersickness (WEECH; KENNY; BARNETT-COWAN, 2019). In terms of infrastructure, maintaining the appropriate glasses, cables, and computers required constant technical support and reservations for equipped rooms — a factor that not all institutions can afford without budgetary planning.

Pedagogically, the adoption of immersive technologies requires teachers’ commitment to align the virtual worksite with curricular competencies. Without this alignment, there is a risk of the activity becoming a “fun laboratory” disconnected from the educational objectives. Therefore, internal policies should provide for workload, teacher training, and inclusion of the tool in the course’s pedagogical project.

POTENTIAL FOR OTHER EDUCATIONAL AREAS

Although the experience described focuses on Architecture, the logic of the “virtual construction site” — or immersive environments that simulate practical situations — can be extrapolated to different courses. For example, in the training of Science teachers, simulating laboratories and safety procedures, or Health courses, exposing future professionals to virtual hospital environments. The key is to combine free interactions (where the student exercises autonomy) and guided tutorials (ensuring structured learning). In addition, the conceptual basis of active methodologies and experiential learning remains valid in these other contexts.

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CONCLUSION

The prototype of the educational construction site in VR demonstrated the potential to bridge the gap in construction education in Architecture, articulating theory and practice in a safe, interactive, and iterative environment. From an educational perspective, it is observed that the immersive experience reinforces student autonomy, promotes "in-action" reflections, and enables interdisciplinary learning, in line with the ideas of Dewey, Kolb, and Schön.

However, the effective adoption of this technology requires institutional preparation, teacher training, and curriculum updating so that the virtual experience is not a one-off, but rather an integral part of a coherent pedagogical project. In this sense, future research can broaden the scope, integrating other areas of knowledge and exploring comparative analyses between different methodologies (such as VR x field visit and VR x physical experimental site). It is also recommended that in-depth research on cognitive load (SWELLER, 1988), associated with prolonged use of VR, seek strategies to balance the realism of the simulation and the well-being of the student.

Finally, this article invites the educational community — not only in Architecture but in various fields — to rethink teaching practices through virtual simulations, understanding them as opportunities for teaching "through doing" and through reflection. Thus, the "virtual construction site" presents itself as a metaphor for any environment where theory and practice need to merge in the training of reflective, critical professionals prepared to deal with real-life challenges.

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