Empowering Teachers With AI-Driven 3D Model Generation for Augmented Reality in Education

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Abstract

The integration of Augmented Reality (AR) and Artificial Intelligence (AI) in education has revealed strong potential to improve student engagement and learning through interactive 3D visualizations; though, the adaption of these technologies in classroom remains limited. Current research identifies several barriers that deters educators from implementing AR-based learning experiences, comprising technical complexity, limited digital literacy, lack of time, and resources limitations associated with creating and integrating 3D educational content. Recent improvements in generative AI technologies have demonstrated promise in democratizing access to 3D content creation through text-to-3D and image-to-3D conversion tools, thus reducing the expertise conventionally required for 3D modelling. To address those identified needs, we developed *Edu3D Builder*, an easy-to-use AR/AI application designed to support teachers in creating AR-enhanced instructional materials. The application assists intuitive text-to-3D or image-to-3D model generation without requiring advanced technical or 3D modelling skills. By streamlining the content creations process, *Edu3D Builder* Application decreases technical barriers, complexity, reduces creation time, and lowers resource demands, making AR implementation more available and scalable within educational ecosystems. The tool is envisioned to assist teachers in integrating immersive and interactive learning experiences into classroom instruction across various subject areas. Future work will include professional development sessions to familiarize teachers with this technology and its pedagogical applications, followed by longitudinal classroom activities to assess learning outcomes, user experiences and opportunities for further enhancement based on collected data.

Keywords: augmented reality, artificial intelligence, 3D content generation, TPACK, teacher adoption, AR authoring, educational technology

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Introduction

Augmented Reality (AR) technologies have attracted sustained attention in the educational research community as tools capable of enriching learning through the overlay of interactive, three-dimensional digital content onto the physical environment (Azuma, 1997; Wu et al., 2013). When learners can visualize abstract concepts as spatially anchored 3D models—whether a cell undergoing mitosis, a historical artifact, or a mechanical assembly—they benefit from heightened engagement, improved spatial reasoning, and deeper conceptual understanding (Akçayır & Akçayır, 2017; Merchant et al., 2014). Compounding this potential, recent advances in generative AI have opened the possibility of producing high-quality 3D assets from simple textual descriptions or photographs, democratizing content creation at a speed and accessibility previously unavailable to non-specialist users (Jun et al., 2023).

Despite this promise, classroom-level AR deployment remains the exception rather than the norm. Large-scale surveys and systematic reviews consistently identify three interrelated barriers that prevent teachers from adopting AR: (i) the steep learning curve of professional 3D modelling software such as Blender or Maya; (ii) the technical complexity of AR authoring pipelines involving multi-step export, calibration, and deployment procedures; and (iii) insufficient digital readiness among in-service teachers when confronted with emerging technologies (Bower et al., 2014; Diegmann et al., 2015; Dunleavy et al., 2009). Existing AR authoring platforms were largely developed for developers, leaving the educator-as-author use case structurally underserved.

This paper presents Edu3D Builder, a novel AI-assisted authoring tool designed explicitly for classroom teachers. Grounded in the Technological Pedagogical Content Knowledge (TPACK) framework (Mishra & Koehler, 2006), Edu3D Builder enables teachers to generate AR-ready 3D models through natural language text prompts or image uploads, bypassing the need for any prior 3D modelling expertise. We describe the design rationale; report results from a preliminary pilot evaluation (n = 5) and outline a future research agenda aimed at empirically assessing pedagogical effectiveness and long-term adoption.

Related Work

AR in Education

Akçayır and Akçayır (2017) identified improved learning performance, increased motivation, and enhanced spatial understanding as primary advantages of AR in education, while cataloguing technical difficulties and content scarcity as persistent challenges. Wu et al. (2013) noted that the majority of educational AR implementations rely on pre-built content rather than teacher-authored experiences, limiting curriculum alignment. Radianti et al. (2020) found that learning outcomes were context-dependent, with the quality and pedagogical integration of 3D content emerging as decisive moderating variables.

Barriers to Teacher Adoption

Bower et al. (2020) found that creation complexity was the single most frequently cited barrier to AR adoption, exceeding hardware cost and institutional support. Researchers confirmed that most classroom AR experiences are authored by researchers or technical specialists rather than classroom teachers. Chang and Hwang (2018) further demonstrated that teachers who received scaffolded creation support produced pedagogically richer AR content and reported higher self-efficacy for future AR integration.

AI-Generated 3D Content and Authoring Tools

The emergence of generative AI models capable of producing 3D geometry from text or image inputs—including Point-E (Nichol et al., 2022), Shap-E (Jun et al., 2023), and DreamFusion (Poole et al., 2022)—represents a structural shift in the accessibility of 3D content production. Liu et al. (2023) demonstrated that text-to-3D generation can produce assets suitable for educational AR with substantially less manual post-processing than photogrammetry-based workflows. However, integration of these generative pipelines into teacher-friendly authoring environments remains largely unexplored. Existing platforms such as CoSpaces Edu and ZapWorks support basic AR creation but require teachers to source or import 3D models independently, perpetuating the content-creation bottleneck.

Theoretical Framework: TPACK

The design of Edu3D Builder is grounded in the Technological Pedagogical Content Knowledge (TPACK) framework, originally proposed by Mishra and Koehler (2006) as an extension of Shulman's (1986) conception of Pedagogical Content Knowledge. TPACK posits that effective technology integration in instruction requires a dynamic interplay among Content Knowledge (CK), Pedagogical Knowledge (PK), and Technological Knowledge (TK). True technology-enhanced teaching emerges in the intersection of all three—the TPACK space—where teachers understand how technology can be deployed to teach specific content in pedagogically appropriate ways.

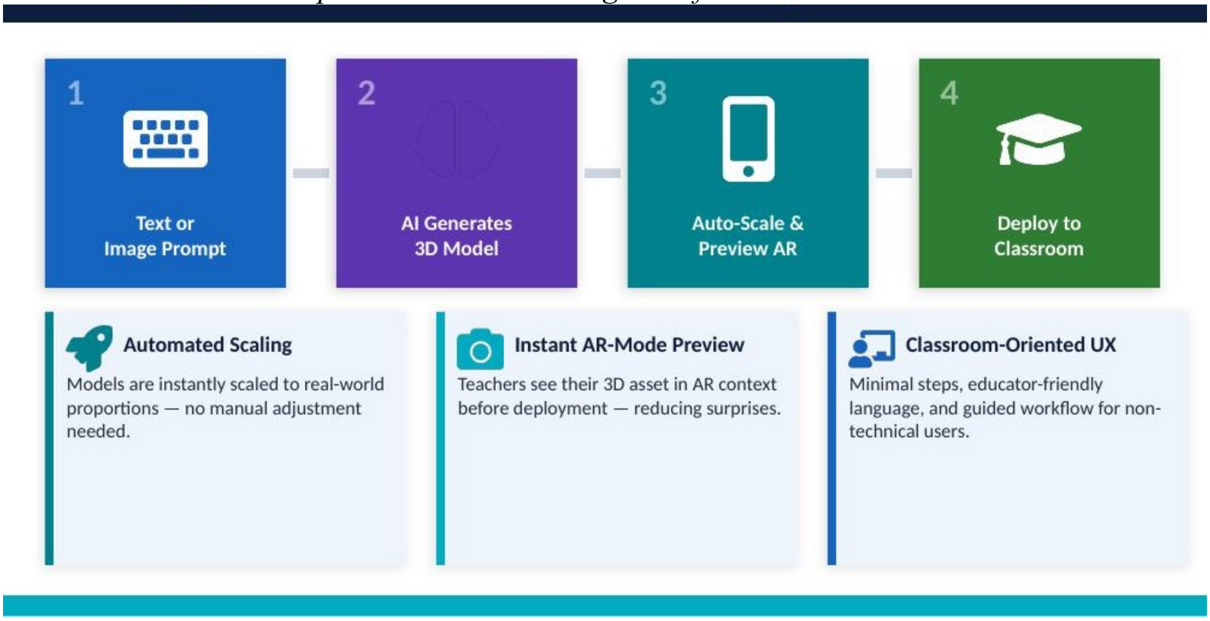
Existing AR authoring platforms tend to address only TK, placing the burden of CK alignment and PK design entirely on the teacher. Edu3D Builder was designed to scaffold all three dimensions simultaneously. The text-prompt interface supports CK by allowing teachers to specify subject-matter content directly in natural language. The automated scaling and AR-preview features reduce TK demands, while enabling teachers to verify pedagogical appropriateness (PK) of the resulting 3D content before class deployment. This TPACK-aligned design philosophy distinguishes Edu3D Builder from developer-centric AR creation tools that prioritize technical flexibility at the expense of pedagogical guidance.

Edu3D Builder: Design and Features

Design Rationale

Edu3D Builder was designed around three core principles derived from the literature review and TPACK analysis: (i) Zero Prerequisite—the tool must require no prior knowledge of 3D modelling or AR development; (ii) Pedagogical Primacy—each design decision must reduce rather than increase teacher cognitive load during lesson preparation; and (iii) Classroom Validity—content generated by the tool must be immediately verifiable in an AR context without additional configuration steps.

Figure 1
Edu3D Builder Four-Step Classroom Authoring Workflow



Note. (1) Text or Image Prompt, (2) AI Generates 3D Model, (3) Auto-Scale & Preview AR, (4) Deploy to Classroom.

Text-to-3D Generation

Teachers enter a natural language description of the desired 3D object (e.g., "a cross-section of a human kidney showing the cortex, medulla, and renal pelvis"). The system routes this prompt to a generative 3D model pipeline that produces an AR-compatible mesh within seconds. Prompt enhancement suggestions are provided inline to improve specificity and generation quality.

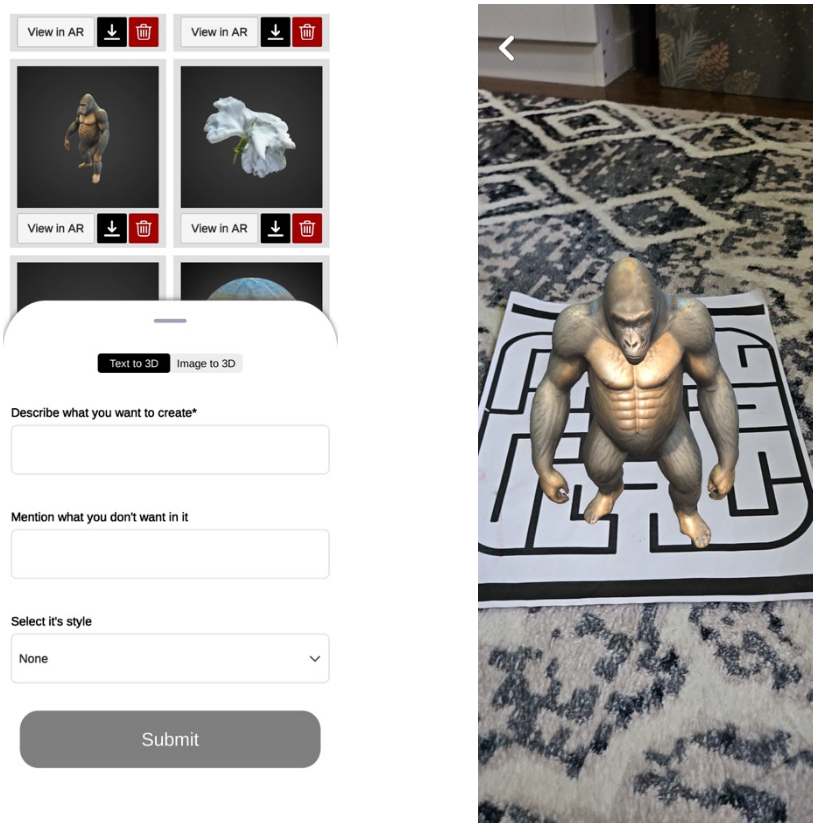
Image-to-3D Generation

Alternatively, teachers may upload a reference photograph—a textbook diagram, a physical specimen, or a product image—and the system generates a 3D mesh by inferring geometry from the provided image. This feature is particularly useful for teachers working with highly specific, curriculum-aligned objects not easily described in text.

Automated Scaling and Instant AR-Mode Preview

A distinguishing feature of Edu3D Builder is physics-based automated scaling, which calibrates the generated model to real-world dimensions based on object-type classification, ensuring that AR overlays appear at educationally appropriate sizes relative to the physical environment. Before saving or sharing a model, teachers can activate an instant AR preview that renders the 3D object in their camera feed using a marker or surface-detection anchor. The complete authoring workflow—prompt entry, model generation, scaling review, AR preview, and export—is designed to be complete in under five minutes.

Figure 2
Edu3D Builder Application Screenshots



(a) Text-to-3D prompt interface. (b) AR marker-based deployment view

Note. (a) Text-to-3D prompt interface showing generated model library with View in AR, download, and delete controls; (b) real-world AR marker-based deployment of an AI-generated 3D model.

Limitations

The pilot study carries important limitations that prevent generalization. The small sample (n = 5), drawn exclusively from the research group, introduces significant selection bias and does not represent the diversity of in-service teacher populations with respect to age, subject area, institutional context, or baseline digital literacy. The study does not address pedagogical effectiveness—whether Edu3D Builder-generated content improves student learning outcomes—a question reserved for the planned classroom-based evaluation phase.

Discussion

The initial findings show promising in validating the central premise of this paper: that by eliminating the needs for 3D modelling, which continues one of the most reported obstacles to AR adaption in education (Bower et al., 2014; Diegmann et al., 2015), generative AI can provide teachers with a less complex AR authoring experience. Participants stated a considerable reduction in perceived complexity, with average rating decreased from 5.8 to 1.8 on a seven-point scale). Moreover, we propose that the TPACK-grounded design supported not only the successful execution of the technical tasks but also fostered a pedagogical mindset among participants throughout the authoring process. For instance, while generating AR content, participant naturally discussed ways in which the generated materials could be integrated into classroom lessons. This indicates that the seamless generative process triggered synchronized pedagogical reflection and content creations, aligning with the TPACK framework on creative technology-enhanced learning designs (Koehler et al., 2007). Nonetheless, several considerations should guide future work. First, teachers may develop expanded expectations regarding the accuracy and customizability of AI-assisted generated models. Educators working with visually precise or field-specific content may still need advanced editing capabilities beyond those presently supported by the tool. Also, issues related to digital equity including inconsistent internet access and institutional policies limiting the use of AI tool features, establish challenges that extended outside usability concern. Addressing these obstacles will demand not only technical improvement but also broader policy development and infrastructural support.

Conclusion

This paper introduces the *Edu3D Builder*, an AI-assisted AR authoring tool designed to reduce the barriers that have historically limited teachers' adaption of AR-enhanced learning in classrooms settings. Grounded in the TPACK model and informed by a literature review of 20 peer-reviewed articles, the tools provided text-to-3D and image-to-3D content generation, automated objected scaling, and instant AR preview capabilities within a workflow specifically designed for K-12 educators. By eliminated the need to create or manipulate complex 3D geometry, *Edu3D builder* removes of the primary technical barriers associated with AR content development. Initial pilot studies with five teachers, indicated that using this tool resulted in a perception of drastically lower complexity compared to existing methods and that all teachers in the pilot were able to produce AR objects in a matter of seconds. While these are exciting early findings, the study results remain initial, with a need to conduct similar trials in the future with larger groups of in-service science and history teachers, measuring levels of TPACK self-efficacy and readiness for digital technologies both before and after the intervention, in addition to performing controlled experiments within classrooms comparing the students' learning outcomes with those in a standard curriculum compared with students using AR. The continued adoption of the tool over a full academic year is being tracked, but we're hopeful that should the field of AI content generation keep evolving and the tool continue to mature as a Pedagogical Content Tool (PCT), then teaching with AR-based teaching may become increasingly accessible to educators across varied educational context, rather than being restricted to classrooms with specialized expertise in 3D modelling and AR development.

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