EDUVERSE

Exploring Gamification and the Metaverse in Architectural Pedagogy

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Abstract. Education relies on a variety of media and participatory activities to deliver knowledge. The recent shift from in-person to virtual learning, led to a dual-stream approach of several challenges, having great impact on the quality of education and student engagement, limiting collaboration and the immersiveness of learning. This paper proposes an alternative gamified online platform designed for architectural education within a Metaverse framework. Eduverse leverages game-engine technology offering a multi-layered infrastructure that combines computational methods, content creation, and user experience design, re-envisioning the conventional curriculum. The effectiveness of the system is assessed by comparing it against existing digital pedagogy literature, and through qualitative analysis of user feedback after testing a live version of the system.

Keywords. Education, Metaverse, Immersive, Gamification, Pedagogy, Experience, Interaction

1. Introduction

Navigating the transition from in-real-life (IRL) modes of interaction to online and hybrid ones, contemporary educational frameworks are also evolving to adapt to the new 'status-quo' by adopting technology. Architecture differs from other study domains, as it employs a variety of resource intensive teaching approaches, and traditionally relies on diverse content, such as images, drawings, videos, and text to deliver knowledge. Participatory activities, such as design studios, on-site research, model making, critiques and the likes, constitute interaction on a personal level, where localities and iterative feedback are essential for successful knowledge transfer. The forceful shift to online education during the recent pandemic revealed significant challenges. With students being unable to commute for studies, the rapid adoption of online classes was necessary, but quite limited. Online classes proved to be very problematic, lacking the essential digital capabilities for collaboration. Furthermore,

ACCELERATED DESIGN, Proceedings of the 29th International Conference of the Association for Computer-Aided Architectural Design Research in Asia (CAADRIA) 2024, Volume 3, 59-68.

hardware disparities led to subpar teaching quality, while emerging online platforms facilitated only the exchange and review of 2D content. Socially, reduced interaction led to poor productivity and motivation, as students missed out on the traditional university experience.

To address the above challenges, this paper introduces a novel online platform for architectural education, that utilizes gamification within a Metaverse environment. Eduverse is built on game engine technologies, integrating diverse computational techniques with digital content creation, and User Experience (UX) design, while re-imagining the traditional curriculum. For the purposes of this paper, we are focusing on a Minimum Viable Product (MVP) that's self-contained. We will delve into existing literature and subsequently conduct a qualitative evaluation of the MVP after its deployment. Our objective is to gauge user intent in regard to the role of technology integration within education, while providing critical insights on how gamification and the metaverse can enrich collaboration, build communities, and engage learning.

2. Background

In architectural education, alternative teaching methodologies are key to meeting contemporary educational challenges. Our approach is inspired by existing approaches such as meta-learning, experiential learning, learning environments, project-based learning, and VR/AR. The rise of CAD systems marked the initial shift towards digital design. Greg Lynn's theory of "Animate Form" (2008) explores the "Paperless Studio" approach to digital design education, firstly introduced by Hanna and Barber (2001). We argue that both digital studios and the broader architectural education curriculum can benefit from two main technologies-concepts. The first one being “Gamification” (Pelling, 2003), as the conception of integrating game elements, into non-game settings to achieve goals (Nand,2019) or into educational environments to enhance learning (Kapp et al. 2012). And secondly, “Metaverse”, as an evolving concept (Stephenson, 1992), that combines various technologies extending beyond just a digital space.

2.1 GAMIFICATION AND ARCHITECTURAL EDUCATION

Eduverse resonates with research on gamification in education, viewing architecture as a spatial design game and games as tectonic constructs. Games, as clearly scoped endeavours of mental of physical activity, offer valuable practice (Çetin, 2013), enhancing problem-solving skills and learning motivation (Gros, 2007). The origins of gamified learning can be traced back to John Locke's 17th-century block-based design (2013), still relevant in modern architecture. Garris et al. (2002) argue that gamification enhances engagement and motivation, as it requires the employment of vital logical and strategic skills to solve spatial problems, something that we attempt to incorporate in our proposal by spatial riddles and rewards.

2.2 METAVERSE AND ARCHITECTURAL EDUCATION

Metaverse users craft virtual worlds with terrains, characters, and props, simulating physics for realistic virtual environments, with immersive qualities that can enhance learning by providing a strong sense of presence and immediacy (Dede, 2009). We argue in favour of an educational Metaverse that transcends traditional 2D learning, enabling students to engage with 3D simulations and collaborate in virtual spaces with avatar interactions promoting social connections (Schlemmer, 2015). Being virtual, the Metaverse grants users the agency for setting their own rules and array of activities from social events to university lectures (Tate, 2016). Eduverse sets to offer interactive learning opportunities, which should be the standard for game-based learning (Prensky, 2007). Finally, architecture and the Metaverse both entail crafting spaces, yet the latter often falls short in detailed design tools available in commercial CAD packages, which respectively lack in providing immersive experiences.

3. Methodology and Implementation

Eduverse is a multi-layered framework structured on User-Discovery research to meet stakeholder needs. It combines computational design for content generation, and game-engine interfaces for creating user experiences. Looking beyond the tech-stack, we put emphasis on the curriculum planning, reimagining governance mechanisms, incentives, and roles within education.

3.1 PERSONA DEVELOPMENT AND EDUCATION PAIN POINTS

We mapped the "day-in-life" of various student personas, carefully identifying and addressing key issues within the current educational journey. Commuting, social pressures and high living costs in cities burden offline learners. In comparison, online learners struggle with obtaining hands-on experience. They have limited peer and teacher interactions, technical glitches, and time zone differences, while self-learning can't replace live guided feedback. Architectural education requires diverse physical spaces for different activities, many times with specialized equipment, but limited to academic or institutional settings (Brocato, 2009). In contrast, online learning restricts students to computer-based work, that greatly affects the experience, as group learning suffers from uneven workload distribution and social loafing. (Blumenfeld et al., 1996). We identify three main pain points in the traditional educational approach as depicted in figure 1 (Left). High cost, poor learning experience and lack of motivation. We aim to provide a solution with our proposal depicted in figure 1 (Right).

3.2 EDUVERSE: A SCALABLE, GAMIFIED IMMERSIVE EDUCATIONAL FRAMEWORK

Our solution addresses these issues by introducing a scalable educational framework. An online platform, that provides virtual classrooms within immersive environments, supported by incentivization mechanisms, aiming to offer maximum learning flexibility. We argue that online-ready content does not only broaden educational reach but also supports hyper-personalized schedules and curriculums. Established academic assessment methods often fail to evaluate students' ongoing development, focusing mainly on final grades. However, the gaming-inspired value token system utilized in Eduverse provides essential and immediate insights into a student's skills. Education is an inherently collaborative process, as such numerous key stakeholders are involved in Eduverse. At the forefront, educators guide students and tailor curricula using the system's resources. Institutions-universities can customize platform features and infrastructure to fit their needs. Our proposal also promotes a decentralized structure, leveraging modular microservices to forge an interconnected educational network bypassing cumbersome admin. Finally, students are the key players of our system.

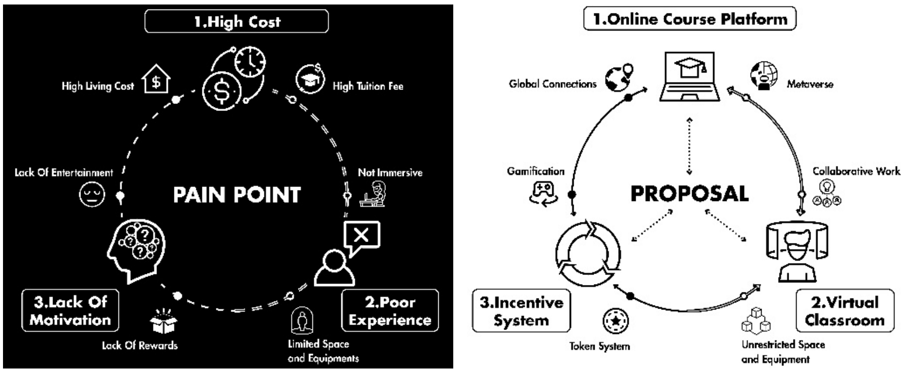

Figure 1. Pain points of traditional education (Left) The elements of the Eduverse framework (Right)

3.3 GAME MECHANICS

In our proposal we attempt to craft a coherent game storyline and establish mechanisms that serve as the design methodology, for the system's digital content. This narrative formulates the user experience and supports the platform's interactive educational features, as shown in figure 2. It consists of five parts: student registration, avatar creation, course planning, interactive content (exploration, learning, entertainment) revolving around a token- reward system, and finally, graduation. In the current iteration of the platform, the teacher's Point of View (POV) timeline was not prioritized. The main differences lie on the performance evaluation mechanisms and the teachers' administrative role, while the supporting technology remains be the same.

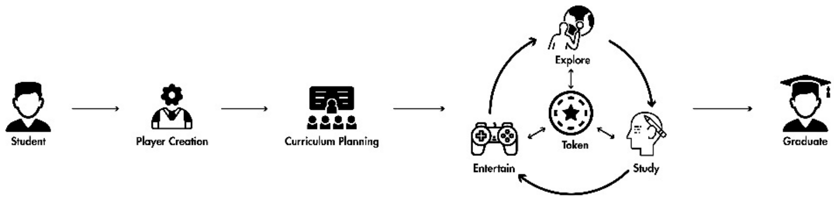

Figure 2. The mechanics and user-experience of Eduverse

Traditional architecture training typically spans 5-6 years, blending foundational skills with complex design principles in a studio environment. However, with architectural design being deeply subjective, students are shaped by their city and school's teaching methodologies. Our goal is to reduce the dependency on physical location and offer versatility by using virtual environments and infinite scalable resources, lessening the importance of geographical identity, making the city the university campus itself, a dynamic educational platform that evolves with the curriculum. While traditional teaching relies on hypothetical projects, assessed through representations of the design, our virtual world enables augmentation within a digital urban system that is everchanging, a complex challenge currently addressed by the CG (computer graphics) industry with solutions like Universal Scene Description (USD) and implementations such Nvidia's Omniverse. Upon logging in and getting assigned their tailormade curriculum, students engage in transforming these city-campuses by exploring, acquiring knowledge, and engaging in digital leisure activities such as games and riddles. We implemented 3 distinct types of classrooms to test the system: History and Theory, Building Technology, and Collaborative Design Studios.

3.4 TECH STACK: GENERATION AND INTERACTION

The tech-stack of Eduverse is divided into two components: the backend and the front-end. The backend is responsible for generating, hosting, and delivering content, while the front end focuses on rendering this content, facilitating real-time interactions between the users and the system. On the backend, we leverage Grasshopper3d for its procedural modeling capabilities. To create the city-campus, we developed automated stochastic processes that analyze and establish spatial relationships, along with generative rules for streets, urban parcels, and buildings. This approach yields a diverse range of urban design possibilities. The next step is to procedurally integrate tectonic elements into the urban fabric using Blender, which excels at managing large polygonal meshes and efficiently mapping material textures. For this version of the application, we have set up system servers locally. The front-end is developed on Unreal Engine 5 (UE5), allowing us to create interactive content via its visual programming interface, Blueprints. This workflow allowed access to a vast array of resources, hence speeding up the production of a vast number of interactive game experiences. We incorporated Ready Player Me, a free-to-use avatar customization plugin, as the foundation for our character creation. Finally, for the UI/UX design, we used Figma, an online collaborative platform, to create the dynamic effects for our prototypes and demos.

3.5 THE TECTONICS OF EDUVERSE

3.5.1 City-Campus Generation

We are rethinking student-to-school commutes by turning them into engaging journeys through digital cities. These 1km² city-campuses are virtual environments that offer diverse architecture, landmarks, and interactive elements, like NPC (Non-playable characters) and quests, enabling opportunities for social engagement in a digital way with classmates. As part of the curriculum, students select a city to explore through the digital twin of its built environment over a full semester. The Grassopper3d procedural modelling back-end allows us to create diverse urban plans and subsequently generate unique structures from a library of architectural elements as shown in figure 3, making it easy to switch styles for building models. Both the macro and micro scale processes are deterministic, such as same inputs will always yield the same outputs, something that we found essential to control the system more effectively, balancing between discrete and continuous control values, generating design-viable solutions.

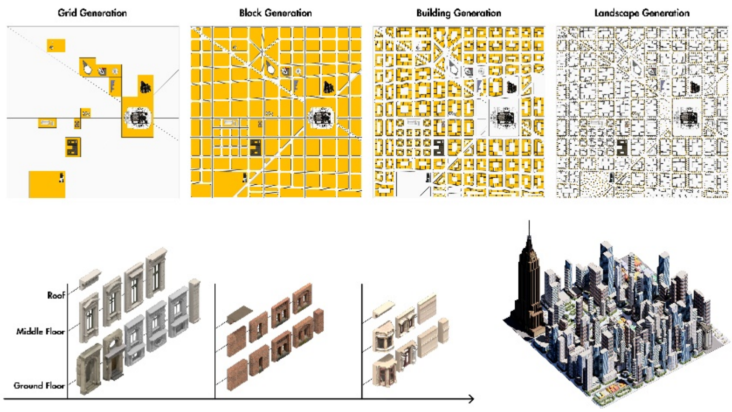

Figure 3. The procedural generation methods of City-Campuses

3.5.2 Student Personal Avatar and Space Generation

To mitigate the loss of physical identity and sense of belonging, we provide our users with the ability to create personalized avatars and study spaces, using our comprehensive in-game component library. This is a common feature of modern gaming, where characters, environments and settings are hyper-personalized. "Ready Player Me" is extended with items fitting the architectural lifestyle and persona. The avatar customization splash screen is displayed on the left-hand side of figure 4, along with a selection of tailor-made student rooms.

Figure 4. The UI of the study room creation and Avatar customization

3.5.3 The Classroom Designs

We evaluate the translation of the traditional curriculum with three new virtual classrooms, as noted in the preceding chapter. The History and Theory class is structured into five distinct sections: an Introduction, a Guided Tour, Interactive Sessions, a Quiz, and finally the Reward segment. As the course commences, participants will be briefed on the learning objectives by an NPC with the educational journey unfolding within iconic landmarks. Eduverse allows for dynamic content display, with billboards of information, presenting historical insights. For example, the students learn as they navigate inside the Barcelona Pavilion by Mies Van der Rohe, with dynamic audio-visual data appearing in relation to their proximity to the content controllers and the point in the timeline of the semester. At the same time wayfinding maps such as the one on the left side of figure 5 assist them with navigation. Our game infrastructure allows students to alter the visual aspects of various components within the study subject, enabling them to explore the intricacies of architectural design. In the end, students obtain rewards by successfully answering questions that test their grasp of the newly acquired historical knowledge.

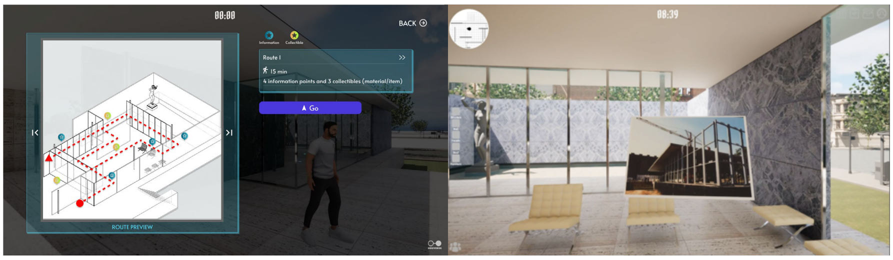

Figure 5. Interactions of the History and Theory class.

The Building Technology class focuses on the exploration of details. The class starts with an introductory overview of a specific tectonic element. Throughout the course, students immerse themselves in hands-on activities, methodically assembling and deconstructing different building components as demonstrated in figure 6. This digital interaction allows them to gain a deeper understanding of each individual part of the building. This class translates the traditional drawing-based technology and detailing course to an interactive exploration of architectural forms. Technical details are available as meta-data attached to each game-object, while assessment and comprehension tests are integrated into the system where students are asked to replicate the parts sequence of assembly. Upon completion of the class, students are rewarded based on their scores and performance.

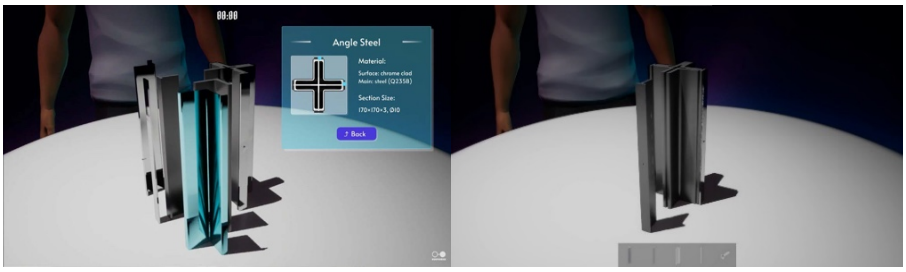

Figure 6. Deconstructing Details in the Building Technology Class

Eduverse also re-imagines the traditional Design Studio in a collaborative way. It offers students a wide range of resources for participatory design and analytical methods, all within an interactive virtual setting. Teachers assign tasks, and students engage in group discussions and presentations, shaping and sharing their ideas. For our MVP implementation, a small selection of tools was developed: basic geometry transformations, sectioning tools, element deconstruction tools and simplified annotations as depicted in figure 7. In addition, students can upload models or other data from commercial content creation packages setting up their own bespoke virtual review spaces. Top-rated student designs are showcased on the virtual campus, replacing existing buildings in the city-campus as a form of recognition for their work.

Figure 7. Interactions during the Collaborative Design Class

3.6 EDUCATIONAL GOVERNANCE THROUGH GAMIFICATION

Our proposal attempts to reimagine traditional incentives with a dynamic game-based reward system where final grades are not the only way to assess performance. Our integrated game token/value framework enables users earn tokens in the form of e-coins by completing coursework, as shown in figure 8. These can be used against digital goods or for unlocking additional functions of the game. Skill Points, reflecting purely educational success, are also gained from finishing courses and while Experience Points, accumulated through city-campus exploration-learning.

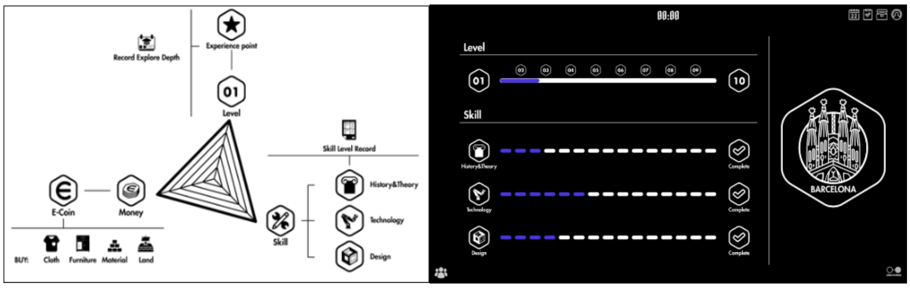

Figure 8. The token reward mechanism (Left) –The skill-based progress within a city-campus (Right)

3.7 CASE STUDY

To evaluate the effectiveness of our system, we will document and discuss an applied case study: a live version of the MVP, for the total duration of ten days available for users to test and experience at the autumn graduate show of the Bartlett School of Architecture, UCL. The demo was locally deployed on a commercially available workstation, while interaction happened via peripherals such as a keyboard, a mouse, and a video-game controller. In terms of gameplay content, we trialled three different classes as separate game levels in a city-campus themed after the city of Barcelona. Following the MVP testing, participants were given a twelve-item survey. This questionnaire included queries that adopted a 1-to-5 rating scale and extended from specific feedback on the system's implementation, to broader inquiries about the future of technology-enhanced learning. While approximately 50 participants initially opted-in to provide feedback, the number of beta-testers was at least quadruple. The respondents mainly consisted of architecture students, professionals, and educators, with students representing the largest group among the three categories.

4. Assessment

Respondents of our survey provided reserved, but positive feedback on the generic technology related points. They rated the introduction of virtual environments into the teaching process, with average rating of 3.61, but underscoring their role in enhancing their understanding of architectural/urban design projects. AR/VR technology integration into design presentations had an average rating of 2.79, indicating that the volume and current weight of the apparatus is not yet allowing it to be considered an integrated tool. At the same time, users noted that realism and immersion depend greatly on quality of materials, pixel-streaming speed, lighting, and contextual sound, with most of them receiving either 4 or 3 points on the rating scale. Finally, opinions vary on the future role of immersive systems in architectural presentations, reflecting the diverse expectations for these technologies in construction. On the Eduverse specific questions of the survey, preferences are split between the controlled multiplayer gamified environment and free game exploration. On the other hand, there is a clear indication of a trend towards social, interactive experiences, from a first-person perspective, as they rated the collaborative design studio higher that the other two classes. More than half of the respondents were in favour of using games in education and 58% believe that virtual environments significantly enhance specific skills, such as the Building Technology module, where the deconstruction of architectural details was received with great enthusiasm. While our system currently lacks the capability to directly capture emotional responses during testing sessions, we believe that implementing automated feedback tools such as usage tracking and click map analysis would greatly enhance future updates. It is important to acknowledge that this initial rollout is constrained by a short timeline and a limited number of participants, which without a doubt can skew the results.

5. Conclusions

Although Eduverse introduces innovative learning elements, it cannot completely replace traditional education, nor is bulletproof against issues related to accessibility and inclusivity, particularly regarding technological infrastructure, essential for democratizing access to education. Instead, what Eduverse is designed for, is the augmentation of educational experiences, especially the ones that relate to spatial design. Nonetheless, incorporating this platform into established educational frameworks necessitates a willingness to embrace new technologies from institutions, which might prove cumbersome, even though it advocates for a decentralized model of governance and curriculum creation. While novel, we acknowledge the current limitations of our proposal. We aim to address in future versions by upgrading interactivity and equipping the back end with more robust generative design processes, while ensuring universal access and integrating more elements of gamification. While considered in our narrative mapping, the teachers/educator's perspective has neither been implemented, nor assessed. The preliminary testing stage was limited, hence system can benefit greatly from additional phases, leveraging cloud-based infrastructure to test its scalability, while aiming for a richer data collection methodology beyond the scope of a survey. Promising solutions might include integrated non-invasive sensory devices on the headsets of users. Devices such as Emotiv Epoc could be utilized to map brain-wave patterns, thus providing insightful data on user engagement and emotional responses within the virtual learning settings. At the same time given the recent release of Spatial Computing devices, the opportunities for further augmenting, both the design and learning processes, are encouraging. Finally, our goal is to enhance the system's flexibility by refactoring the core infrastructure, allowing coursework and class-specific microservices to interoperate seamlessly, creating a more comprehensive and diverse curriculum.

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