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A Game Engine Based Interactive and Collaborative Architectural Education Model Proposal

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Abstract – Learning constitutes the act of inducing enduring behavioral changes. Although it can be dissected into three main categories—cognitive, affective, and psychomotor—research suggests that active student engagement leads to more effective education, regardless of the subject or field.

From a contemporary standpoint, the concept of "technology in education" has gained prominence, influencing modern pedagogy across various domains. Applications that leverage technology to engage visual, auditory, and tactile senses have significantly supported experiential learning methods, sparking innovation in numerous scientific disciplines. Present-day students, immersed in the technology era, particularly through social media and gaming, are redefining the learner profile and shaping the technological dimension of education across all scientific domains.

In the realm of architectural science, a fundamental principle is the comprehensive understanding, planning, and imparting of knowledge and skills related to 3D volumes, considering aesthetic considerations. Additionally, the cultivation of a critical thinking system for dissecting theoretical knowledge is a distinct goal. With technological advancements, architectural pedagogy, especially in the education of 3D thinking, design, and digital presentation, has undergone a paradigm shift.

Within this conceptual framework, this study proposes an interactive and collaborative educational model, supported by the Unreal Engine (UE) game engine, for architectural pre-design processes. The study focuses on the pre-design phase and involves experiments with architecture and interior architecture students from various classes who possess experience with fundamental architectural design and modeling software. The study presents the efficiency and future prospects of the model by sharing software-based approaches using the UE game engine and the design outcomes achieved through its utilization.

Keywords – Architectural Design, Collaborative Design, Interactive Design, Unreal Engine, Pre-Design, Educational Model

I. Introduction

Learning is the act of inducing permanent behavioral change. Although closely related, it is examined under three main categories: "cognitive," "affective," and "psychomotor". Research indicates that active student engagement in the learning process enhances the effectiveness of education across all subjects and disciplines. In this regard, experiential learning approaches have garnered attention in educational science and have been introduced into the literature as the "constructivist approach" [1].

From a contemporary perspective, the concept of "technology in education" has emerged, influencing modern pedagogy in various fields. Applications aiming to engage visual, auditory, and tactile senses with the support of technology have particularly bolstered experiential learning methods, prompting numerous scientific disciplines to adopt this approach [2]. Today's students, who have grown up in the age of technology, especially with a focus on social media and game-oriented experiences, are defining a new “profile” and shaping the technological aspect of education across all scientific domains.

In the field of architecture, which is one of these domains, the essential goal is to comprehensively grasp, plan, and impart knowledge and skills for production, considering aesthetic concerns for 3D masses. Additionally, the cultivation of a critical thinking system for analyzing theoretical knowledge is also emphasized [3]. The advancement of technology has led to a shift in the pedagogy of architectural science, ushering in revolutionary innovations in the education of 3D thinking, design, and digital presentation.

In this context, approaches such as virtual reality, simulation, and augmented reality, which are advanced software technologies of our time, have captured the attention of architectural pedagogy. The use of these technologies in education has the potential to reduce spatial and temporal costs, enhancing the learning experience and eliminating time and space constraints. Therefore, the use of technology in education and research conducted in the field of educational technology can have broad applicability [4].

Focusing on the conceptual framework outlined above, this study proposes an interactive and collaborative educational model supported by the Unreal Engine (UE) game engine to enrich the architectural pre-design process. The scope of the study specifically targets pre-design education spaces, with preparations tailored accordingly. Experimental work was conducted with a group of architecture and interior architecture students from various classes who possessed experience with fundamental architectural design and modeling programs. Initially, an empty architectural volume was constructed, and a software-based method was developed for students to select and design various divider and furnishing elements in line with the fundamental architectural criteria. The study shares the results of the design obtained through the use of the UE game engine-based software approaches and the model’s efficiency, opening up discussions about its future prospects.

II. Literature Review

Several studies related to this research and others that could contribute to its advancement have been examined. These studies have particularly drawn attention due to their connection to perceptual richness and advanced experiential learning, motivating the reinforcement of VR support for the model developed within the scope of this study. Furthermore, the studies reviewed have yielded significant results in terms of educational outcomes in technology-centered architectural education. Hence, the literature review has provided direction and added vision to this study.

In [5], the study focused on the contribution of virtual reality (VR) technology to architectural education. The primary aim of the research was to explore the theoretical possibilities of VR technology that enable students to examine architectural components and relationships in an interactive and participatory educational environment. The study demonstrates that the adoption of virtual reality systems in architectural education could make a positive contribution to the design discipline.

[6] introduces digital gaming as a new, futuristic learning technique in architectural education based on the common ground between game design and gameplay processes. The study emphasizes the importance of engaging students in learning, from exploring possibilities under specific constraints to decision-making, and introduces digital gaming as a novel learning approach in architecture. This work is significant in making design education enjoyable and constructive, offering new opportunities in architectural design.

The study by [7] describes a prototype study conducted to test the feasibility of providing architectural education to architecture students using video game technology. The prototype application modeled a proposed urban area using the Unreal Engine, allowing a group of architecture students to navigate the virtual environment. Subsequently, their experiences were surveyed, and the results were discussed.

In [8], the researchers examined the advantages of VR over traditional methods for studying pioneering works in the field of architecture. By simulating Therme Vals as a serious game, they observed that the study group could effectively recall the spatial configuration and suggested that VR technology could replace visiting pioneering works. They also highlighted that this method, with user interaction, provided a better, cheaper, and easier way to access original architectural knowledge.

[9] presented a systematic review of how extended reality (XR) technologies impact learning outcomes and student performance in architectural education. The results indicated that XR technologies, including VR, AR, and MR, can enhance various stages of the design process and improve learning outcomes among architectural students. Similarly, these environments were found to be suitable for professional architectural design and for involving end-users in the design process.

III. Materials and Method

In this research, an architectural educational environment was designed using Unreal Game Engine. The study was structured with a collaborative and multiplayer approach. The initial version of the model, which is the subject of this study, was designed for a preschool education environment, and the necessary preparations were made within this scope. A diagram summarizing the operation of the model is presented in Fig. 1. The functioning of the model, designed to feed into the architectural pre-design process, is explained step by step below. First, input parameters will be discussed, followed by an introduction to the system's operation, and finally, output parameters will be described.

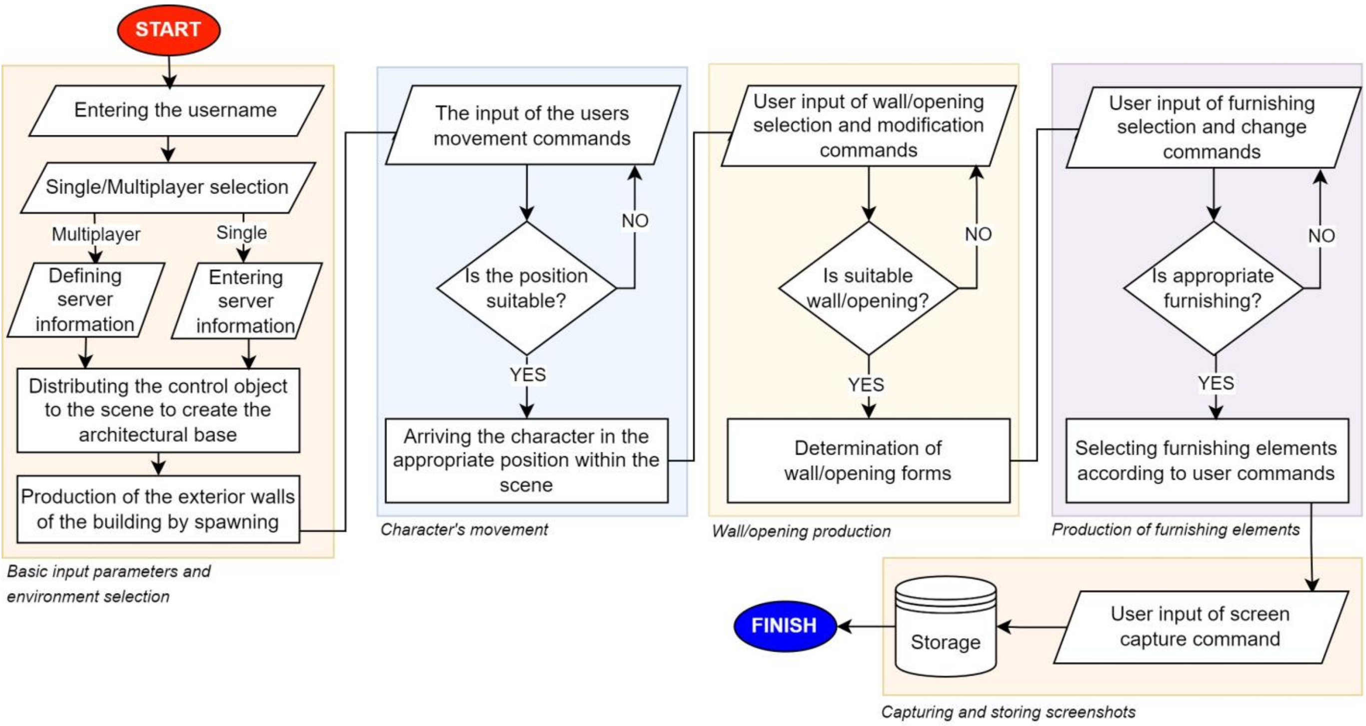

Fig. 1. Model Diagram.

3.1. Input Parameters

When the software is launched, the user is initially prompted to enter their name. Following this, the user is asked to make a choice between "single" or "multiplayer" access in the opened window.

If the user selects the multiplayer option, they are asked whether they will create a new environment or connect to a previously established one. If they choose to set up a new environment as the server, they are required to specify two pieces of information: the "environment name" and the "connection password." This way, the user can connect to this newly created environment, and other users who share the information can also join. If the user wants to connect to a previously established environment, they should select this option and then enter the information shared by the creator (server) to connect.

Once these steps are completed, a common 3D design space is opened for all users who have entered the system with the same information. Thus, all users can navigate in this open environment and experience it by designing within it.

After connecting to the environment by entering these basic parameters, users can move within the environment and define walls and furnishing elements using keyboard and mouse inputs. At this stage, users can select and place furnishing elements in appropriate positions and rotate these elements at their center, allowing for flexible design of the environment.

Finally, users are provided with the opportunity to capture an image of their design on the screen and save it to the computer by making another keyboard input.

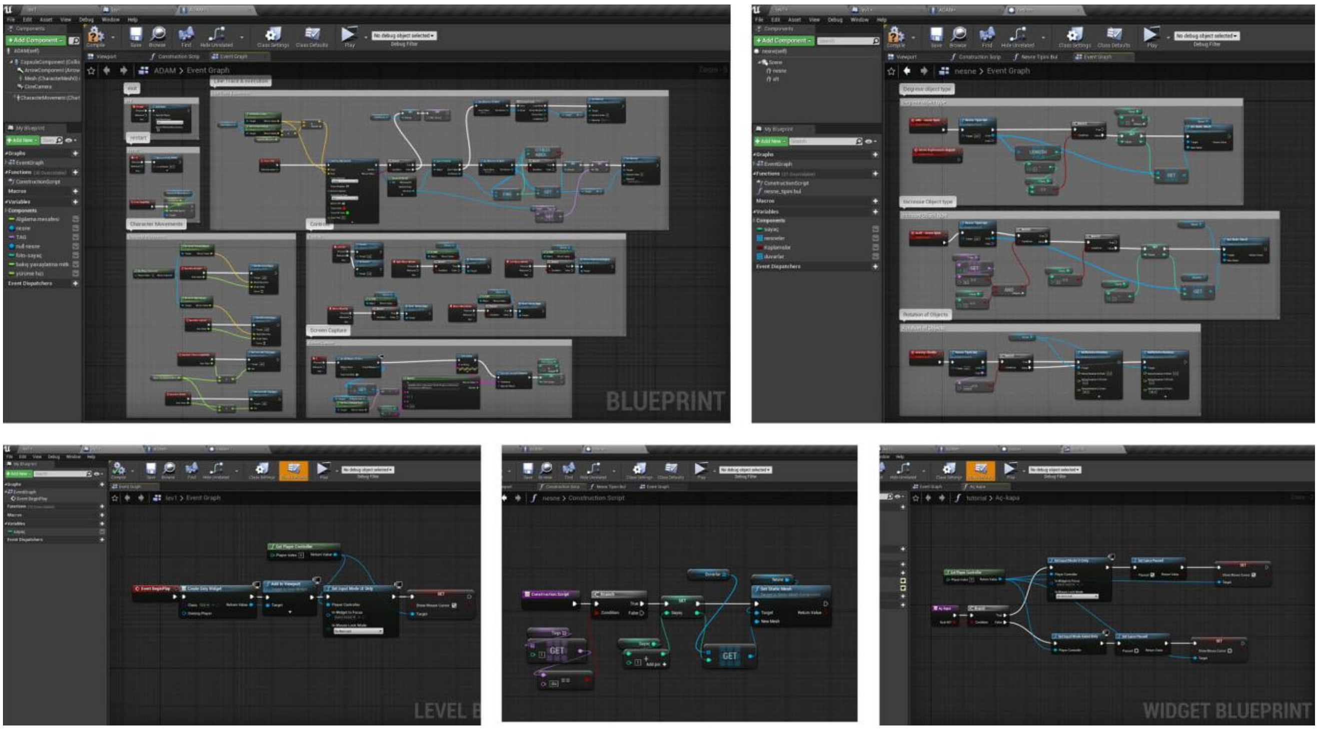

Fig. 2. Views from the Blueprint coding screens of various classes in Unreal Engine environment.

3.2. System Operation

The system was developed on the Unreal Engine 4.26 platform. As seen in Fig. 2, the system was made operational through the necessary software developments in the Blueprint coding interface of Unreal Engine. An important software method used in the model is “Line Trace By Channel,” which allows interaction with the point where a ray sent from the camera objective vertically intersects the ground (Fig. 3). This method enables the selection of different wall/opening models in “wall/opening” types and alternative furnishing types in “furnishing” types from the points on the floor.

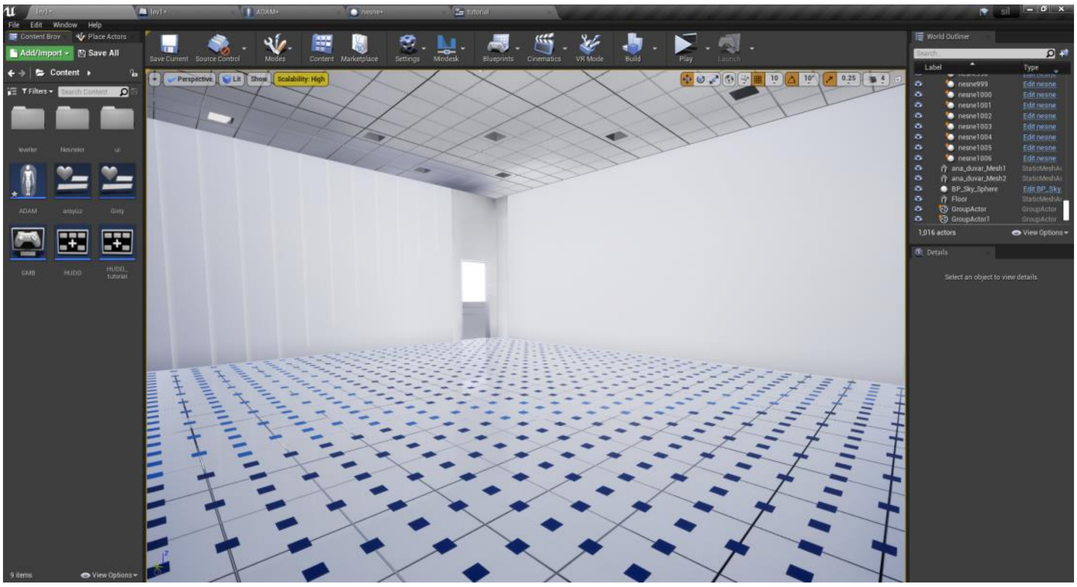

Fig. 3. View from the working environment

To set up the multiplayer system, operations were carried out through the Steam platform. While it caters to a limited number of users, this platform was considered sufficient for initial testing purposes.

The developed model was designed with a modular approach to create any architectural environment. Any wall, opening module, or furnishing element loaded into the model can be included in the system. However, for the initial scope of the model's development and testing, wall/opening and furnishing elements related to a preschool education environment were preferred.

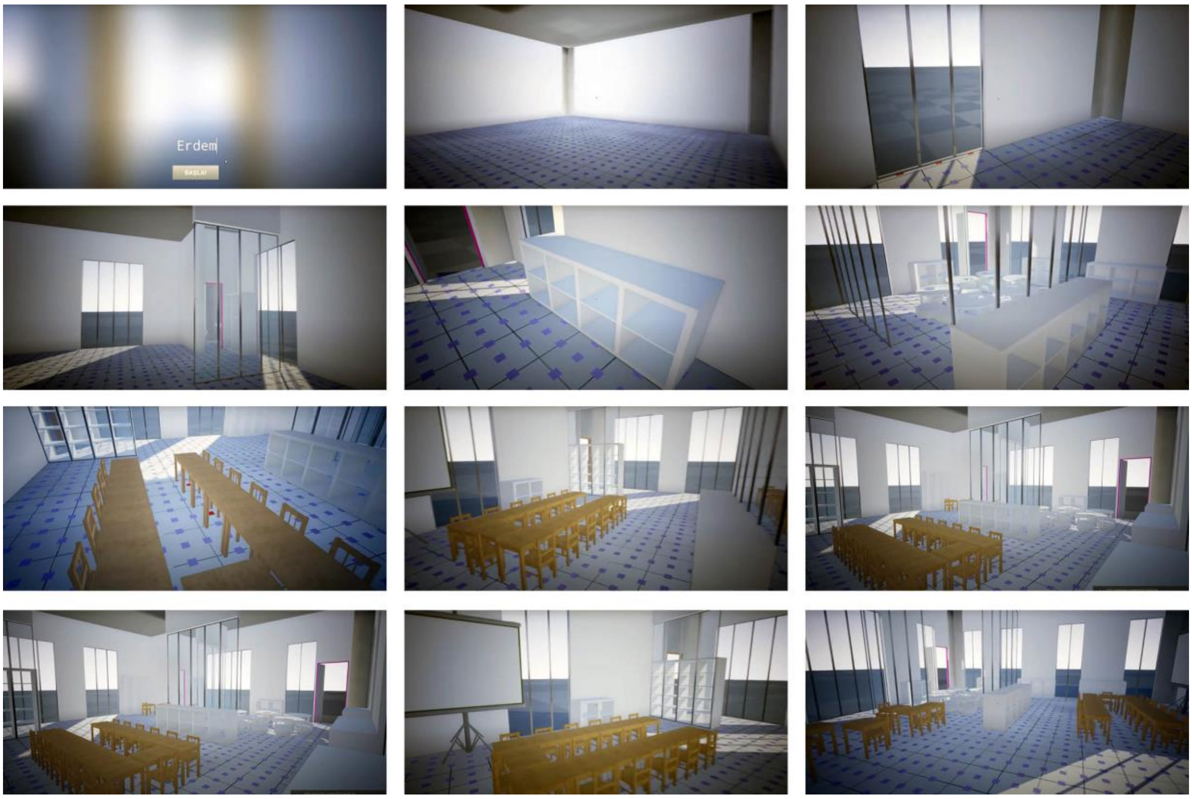

Fig. 4. Screenshots from the model's operation.

In Fig. 4, screenshots from the operation of the study are shared. The visuals depict the step-by-step design of the virtual space by virtual users. Users reach the points on the floor of the volume with completely closed and empty walls from the screen to convert the walls into windows or openings. Additionally, users place elements such as cabinets, tables, chairs, and projector screens belonging to the preschool education volume that have previously been loaded into the system within the volume.

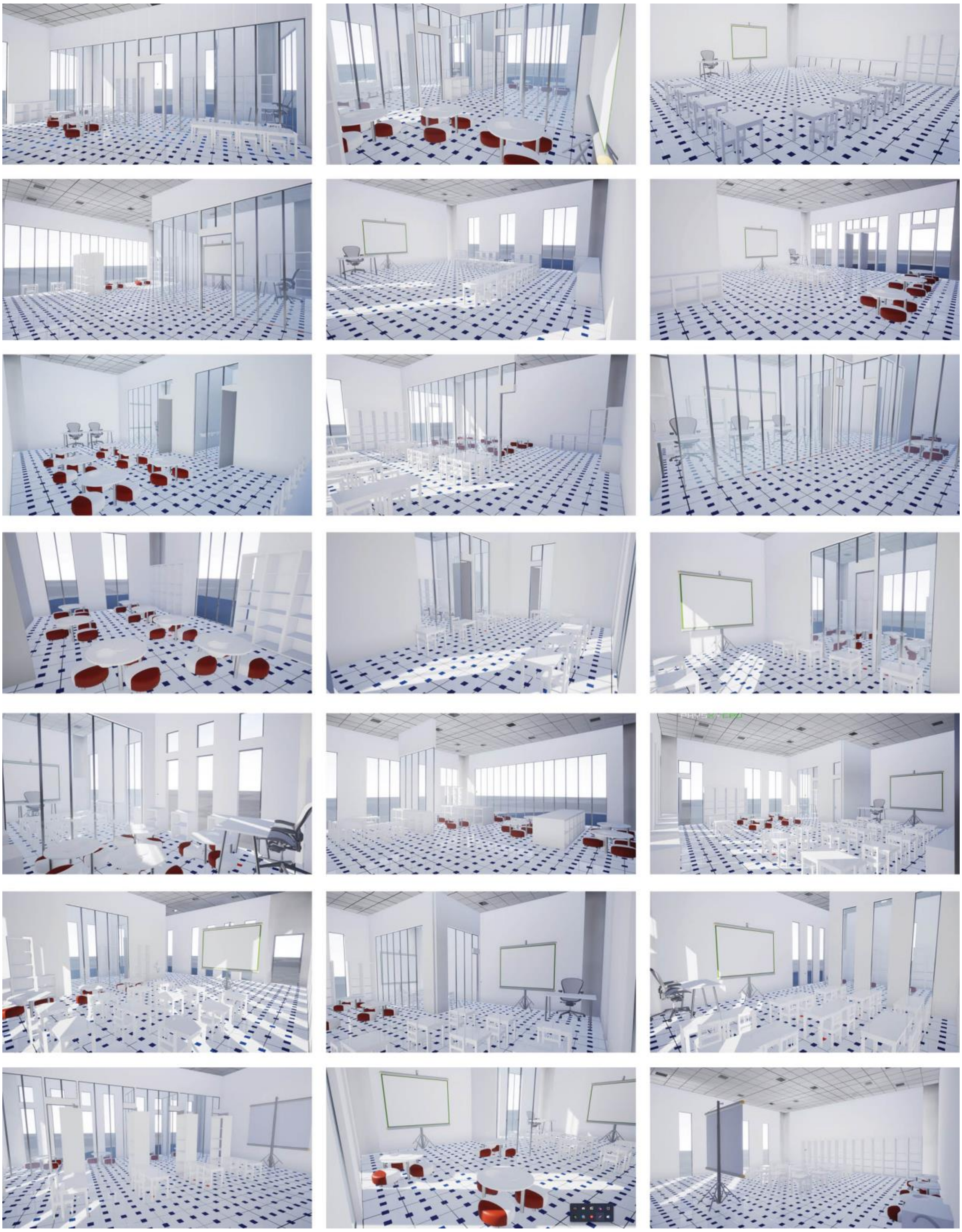

Fig. 5. Examples from student work.

IV. Results

Fig. 5 presents examples from student work. As seen, students have designed the volume with various design approaches using the elements supported by the model. In some examples, partitions were not used, leaving the volume completely empty, while in others, the main volume was divided into smaller sub-volumes with partitions. Some examples show users choosing to scatter furnishing elements, while others show more organized placements. The use of exterior walls by users also varied. In some examples, the facade was opaque, while in others, it was more transparent. However, in all examples, the designs were completed in terms of design as a preschool education volume.

IV. Conclusion And Discussion

In this study, a collaborative and interactive design environment was developed with an interdisciplinary approach to create an architectural education model. The model, developed using Unreal Game Engine, focused on the concept of a preschool education space within the scope of this study. The model received positive feedback from students, who found it engaging and generally successful. As a result of the initial trials of the model, it can be said that it achieved positive educational outcomes.

The study primarily focused on the design of a preschool education space and the model was designed with modules related to this volume. The model was developed to accommodate different architectural modules such as walls/openings and furnishings. Successful educational results were obtained in the design of the preschool education volume. In addition, the system should be updated to respond to different architectural types, and experiments should be conducted to test its educational effectiveness.

In this study, the model was developed with a "First Person Shooter" (FPS) camera perspective, and characters moving within the volume can only see each other's names. It is thought that using an "avatar" in the system, inspired by video games, might be more effective in terms of user adoption and engagement, considering the profile of today's users. This aspect should be considered as a separate research topic in terms of perception. In the next version, experiments will be conducted to switch to a Third Person Shooter (TPS) camera perspective. In summary, the system should be tested educationally with different camera perspectives and avatar usage.

The first version of the model developed in this study does not include a voice or text chat system. Especially for more effective remote education, adding voice and text chat modules would be beneficial. The educational capability of the system should be retested with these additions. Additionally, in terms of architectural education, different qualities should be given to the course instructor or individuals in the environment, such as muting or removing the other users in the environment or sharing documents or screens. Defining extra features like these would be useful. These features, which are predicted to have a high contribution to the model educationally, are planned to be added in the new version of the model. The educational effectiveness of the system should be re-examined with these additions.

As seen in the literature review, advanced design environments often focus on virtual reality [5], [8], [9]. Especially considering its potential in perception, it is believed that establishing a VR connection for the model developed in this study could be beneficial. Since the model is designed collaboratively with remote access in a virtual environment, the addition of a VR plugin is seen as a potential contribution in terms of perceptual aspects.

With the increasing importance of "remote education," especially due to the pandemic, this model is considered to be efficient, particularly because it includes a multiplayer approach. Currently, the system operates on the PC platform. It is thought that moving the system to the web platform could provide faster access and update control. Thus, the model is expected to contribute more to "remote education."

In this study, the multiplayer system was tested with limited access via Steam in UE. To enable access for larger users, different online systems such as Amazon Gamelift, Unity Gameserver, Playfab, or on-premise should be used.

In their study, [7] tested the feasibility of providing education to architecture students using video game technology and found that interactivity and photorealistic tendencies could enhance the quality of education. Similarly, this study should also improve its rendering quality. Using Lumen via UE5 can achieve more realistic lighting and environment to enhance the sense of reality.

In [9] study, XR was experimented with, and the educational contributions of the environment were revealed. This model could be expanded by integrating it with these and similar emerging technologies. After these expansions, the model should be tested again with users, and its educational success should be evaluated.

Testing the developed model in a metaverse environment is also considered important for other versions. This option is emphasized because it is a current and accessible platform for everyone. Opening the model to access in this environment allows users to design without installing additional software. With various organizations opening branches and using this environment for museum purposes and commercial relationships, it is observed that the environment is developing and gaining recognition day by day. Taking into account the potential of the metaverse environment, it is thought that a forward vision can be drawn for the development direction of the model.

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