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DESIGN AND DEVELOPMENT OF A NOVEL INSTRUCTIONAL MATERIAL FOR VIRTUAL REALITY BASED TEACHING FOR ART HISTORY COURSE*

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Abstract

Art history classes can be challenging for students without an art history background. Recognizing these challenges is the first step to finding practical solutions. The integration of innovative digital technologies into art history classes is a creative way to discover novel delivery methods and could also help motivate students and enhance their learning. Virtual Reality (VR) visualizes abstract concepts and theories and allows students to virtually visit historical sites with a sense of presence. Research is focused on creating educational material with two different VR approaches, 3D animation, textual information, and photos for an undergraduate level Art History course on the Süleymaniye Mosque in Ottoman Religious Architecture. VR-integrated course material development needs well-designed multidisciplinary collaboration. A collective effort was needed to determine the competencies and digital technology-based delivery methods by experts in art history, architectural history, educational sciences, and graphic design disciplines. The educational material includes VR-based (6DOF) walk-through software and Quicktime VR-based (3DOF) panoramic photos, 3D animated narratives, and textual-photographic information about the building. Once materials were developed, they were demonstrated to a small group of teachers, research assistants and students in a VR technology-equipped classroom. The feedback from the participants showed that the instructional material was qualified to positively affect the students' level of interest, learning, and retention. This innovative approach has significant educational potential, however its realisation depends on tight collaboration between course teachers, educational specialists, designers and IT specialists, which is not always easy to access.

Keywords: Virtual reality, instructional design, teaching materials, art history education, computer-assisted instruction, the Süleymaniye Complex.

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SANAT TARİHİ DERSİ İÇİN SANAL GERÇEKLİK TEMELLİ ÖZGÜN BİR ÖĞRETİM MATERYALİ TASARIMI VE GELİŞTİRİLMESİ

Öz

Sanat tarihi dersleri, sanat tarihi geçmişi olmayan öğrenciler için zorlayıcı olabilir. Bu zorlukların farkına varmak, pratik çözümler bulmanın ilk adımıdır. Yenilikçi dijital teknolojilerin sanat tarihi derslerine entegrasyonu, yeni sunum yöntemlerini keşfetmenin yaratıcı bir yoludur ve aynı zamanda öğrencileri motive etmeye ve öğrenmelerini geliştirmeye yardımcı olabilir. Sanal gerçeklik (VR), soyut kavramları ve teorileri görselleştirir ve öğrencilerin tarihi mekânları sanal olarak ziyaret etmelerini sağlar. Araştırma, Osmanlı Dini Mimarisinde Süleymaniye Camisi üzerine lisans düzeyinde bir Sanat Tarihi dersi için iki farklı VR yaklaşımı, 3D animasyon, metinsel bilgi ve fotoğraflarla eğitim materyali oluşturmaya odaklanmıştır. Sanal gerçeklikle entegre ders materyali geliştirme, iyi tasarlanmış çok disiplinli bir işbirliğine ihtiyaç duymaktadır. Çalışmada sanat tarihi, mimarlık tarihi, eğitim bilimleri ve grafik tasarım disiplinlerindeki uzmanlar tarafından yetkinliklerin ve dijital teknoloji tabanlı sunum yöntemlerinin belirlenmesi için ortak bir çabaya ihtiyaç duyulmuştur. Eğitim materyali, VR tabanlı (6DOF) gezinti yazılımı ve Quicktime VR tabanlı (3DOF) panoramik etkileşimli fotoğraflar, 3D animasyonlu anlatımlar ve bina hakkında metinsel-fotoğrafik bilgiler içermektedir. Materyaller geliştirildikten sonra, VR teknolojisi ile donatılmış bir sınıfta küçük bir öğretmen, araştırma görevlisi ve öğrenci grubuna tanıtılmışlardır. Katılımcılardan alınan geri bildirimler, öğretim materyalinin öğrencilerin ilgi, öğrenme ve kalıcılık düzeylerini olumlu yönde etkileyecek nitelikte olduğunu göstermiştir. Bu yenilikçi yaklaşımın önemli bir eğitim potansiyeline sahip olduğu, ancak hayata geçirilmesi kurs öğretmenleri, eğitim uzmanları, tasarımcılar ve BT uzmanları arasındaki sıkı bir iş birliğine bağlıdır ve bu iş birliğine erişmenin her zaman kolay olmadığı sonucuna varılmıştır.

Anahtar Kelimeler: Sanal gerçeklik, öğretim tasarımı, öğretim materyalleri, sanat tarihi eğitimi, bilgisayar destekli öğretim, Süleymaniye Külliyesi.

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Introduction

Art history courses, with their interdisciplinary approach, investigate the artwork itself, the history of artworks, and the cultural contexts of the periods they represent. This multidisciplinary nature of art history education requires not only distinctive teaching strategies that keep the student active and engaged but also enriched course materials that make these strategies possible. Chtena (2021) drew attention to the fact that Art History courses are based on books written in a dry, matter-of-fact style, although they are full of quality visuals. She also pointed out that these courses are traditionally conducted in a lecture-based, transfer-of-information model, avoiding active learning, and it has become increasingly difficult to generate interest in the field among today's university students. Recognizing these challenges is the first step toward finding effective solutions. To address these challenges, we can use innovative technologies to reconsider the learning context and its meaningful transformation. In this sense, immersive learning technologies are garnering growing interest among educational technology practitioners (Cecotti et al., 2024).

Virtual Reality (VR) has been used in training across many fields for a significant period as an immersive technology known for its remarkable alignment with educational theories and practice. Mohsen and Alangari's (2023) research indicates that the integration of immersive technology in education is rooted in several prominent educational theories, including Socio-Cultural Theory, Situated Cognition Theory, and Cognitive Load Theory. In the Cognitive Load Theory (CLT), since working memory can process limited information at the same time if the cognitive load exceeds the limit that can be processed, learning is incomplete, and learning motivation can be negatively affected (Mayer, 2024; Mayer, 2001; Sulisworo et al., 2024). Information processing in working memory is managed by the *Central Executive* and information processed by *Visio-Spatial Sketchpad*, *Phonological Loop* and *Episodic Buffer* (Baddeley & Hitch, 1974; Pezzulo, 2007). In this context, the visual and auditory multimedia elements used in VR are compatible with the working memory processes in CLT (Marougkas et al., 2023). A study conducted by Haryana et al. (2022) with 173 participants concluded that the use of VR media in teaching has the lowest cognitive load of the individual compared to the use of audiovisual media, and the learning performance is the highest under these conditions. This study can be presented as evidence that VR instructional materials are a way of balancing cognitive load when designed correctly. In addition, VR supports the learning process by providing immersive and interactive experiences according to Constructivist Theory. According to Chen (2010), constructivism, as a learning theory that argues that knowledge is constructed through the interaction of the individual with his/her environment, emphasises the combination of inputs from the senses, existing knowledge and new knowledge to develop new meaning and understanding. Marougkas et al. (2024) underlined that "Virtual reality (VR) provides learners with a beneficial and engaging experience" (p.18185). Immersive VR also results in enhanced student engagement, improved knowledge retention, and the development of practical skills (Familoni & Onyebuchi, 2024). As in other disciplines VR technology has the potential to enrich Art History education with their visual and interactive possibilities. Roussou (2001) pointed to the fact that VR technologies can allow visitors to travel through space and time without stepping out of the museum building as a particularly interesting feature for museums with growing educational functions. Although the immersive level varies according to the VR technology integrated into the art history course, learners experience the artworks or historical buildings that are the subject of art history through a spatial visualisation that closely resembles real-life experiences. VR experience provides the sense of physical presence on a human scale and contributes to rich learning with visualisation from various scales and perspectives.

Creating VR-based instructional content demands meticulous planning and creative effort to deliver targeted and authentic learning experiences. First and foremost, it is vital to conduct a thorough analysis and determine which educational objectives can best be reinforced through VR. Making informed decisions about the integration of VR into the curriculum is paramount. Existing software may only sometimes be sufficient to achieve the target. Depending on the training requirements, a specially tailored VR application may need to be developed. Additionally, the creation of all digital assets for the virtual environment poses a significant challenge. Consequently, developing a robust VR-based course material necessitates a collaborative, multidisciplinary approach, which may present some obstacles and not always easily accessible.

Statement of the Problem

How could one develop a virtual reality application to enhance learning, generate greater student interest, and contribute to improved learning outcomes and knowledge retention when utilized as an instructional model in Art History courses offered within the Faculties of Fine Arts and Architecture?

Aim of The Study

In this study, we aimed to design and develop an educational application that will facilitate the use of virtual reality in Art History courses at the Faculty of Fine Arts and Faculty of Architecture. To achieve this goal, the research sought answers to the following questions.

Research Questions

(1) How is the development process of the Educational Virtual Reality application?

(2) What are the opinions of the lecturers, teaching assistants, and students about the Virtual Reality Application?

A. METHODOLOGY

The ADDIE model guided the development of educational materials in this study. The five phases of the model are analysis, design, development, implementation and evaluation (Reinbold, 2013). Widely utilized in instructional design across various fields, the ADDIE model offers a systematic framework for creating educational resources (Fang et al., 2011; Kharki et al., 2021). Its simplicity and adaptability to diverse learning needs and preferences make it a potent tool in instructional material design (Cheung, 2016). Although it does not require a strict and linear progression, each step in the ADDIE model has an impact that reinforces the next step (Spatioti et al., 2022). Each step of the ADDIE model in our study is explained in detail in the following sections:

Analysis Phase: During the analysis phase, the requirements for the development of the application were determined based on expert opinions. We sought expertise from academics in art history, architectural history, and educational sciences to help determine the content of the educational material. This process ensured that the topics to be covered in the pilot application and the selection of a sample historical building (the Süleymaniye Complex) aligned with the existing course curriculum. Two primary competency objectives have been established for the educational software based on expert opinions. Furthermore, specific competencies have been identified for these key objectives and are detailed in the following section.

Design Phase: In the design phase, we focused on creating the educational software architecture. This involved modelling digital assets, creating mapping textures, crafting scenarios for narrated videos, and designing the interface graphics.

Development Phase: During the development phase, our main objective was to create a real-time three-dimensional walk-through application. Additionally, we completed coding for the interface, production tasks for the animation videos, and integration of all the parts. The development process, as detailed in the following sections, consists of four main phases:

(1) Creating digital assets,

(2) Programming the 3D Interaction Environment,

(3) Production of narrative 3D animations,

(4) Designing the interface and adding enriching content of instructional material.

Implementation Phase: Moving on to the implementation phase, we presented the educational material to a small group of lecturers, research assistants, and students. We gathered their feedback on the educational aspects of the material.

Evaluation Phase: Finally, in the evaluation phase, we revised and finalized the material based on the suggestions for improvement provided by the lecturers, research assistants and students.

Materials and Software

In the process of creating the application, we utilized detailed technical drawings, including plans, sections and views of the selected building, along with photographs and comprehensive sources containing encyclopaedic information. Our innovative approach to transforming this information into an educational application involved the use of prevalent 2D and 3D computer-aided design programs (AutoCAD and 3D Studio MAX), computer programming languages (DarkBASIC), a video editing software (Adobe Premiere), an interactive interface design software (Macromedia Director), an image processing software (Corel PHOTOPAINT) and DirectX 3D function libraries.

B. EDUCATIONAL SOFTWARE OBJECTIVES AND TARGETED COMPETENCES

The core competencies identified, in collaboration with researchers and experts, during the analysis phase, are presented below and classified under two main categories. Additionally, specific competencies are outlined in a separate list for two distinct key competencies.

Key Competency 1: Recognizing the structure, aesthetic characteristics and functional aspects of architectural structures.

Key Competency 2: Gaining familiarity with general information about architectural structures.

Specific Competencies for Key Competence 1

(1) To tell/ write/ mark from the options the information about the systems designed for the robustness of the structure,

(2) To distinguish the features of columns, pillars, arches, weight towers, and tensile bars from other architectural elements of the building.

(3) To tell/ write/ mark from the options the roof systems used in the building.

(4) To distinguish the roofing system used in the building from other roofing systems.

(5) To tell/ write/ mark from the options the transition elements used in the building and their basic functions.

(6) To tell/ write/ mark from the options the decoration and ornamentation features of the building.

(7) To tell/ write/ mark from the options the features of the decoration and ornamentation elements of the building such as Stone Ornament, Window Vitrays (stained glass), and Tiles.

(8) To tell / write / mark from the options the information about the symbolic expressions in the building.

(9) To tell/ write/ mark from the options the features of the structure related to the proportion scale.

(10) To tell/ write/ mark from the options the features of the building related to Layout, Plan Features, and Usage

(11) To tell / write / mark from the options the main function of the soot chamber in the building.

Specific Competencies for Key Competence 2

(1) To tell/ write/ mark from the options the information about the construction materials used in the building.

(2) To tell/ write/ mark from the options the reason for the construction of the building.

(3) To tell/ write/ mark from the options the architect of the building.

(4) To tell/ write/ mark the location of the building (city and region).

(5) To tell/ write/ mark from the options the other masterpieces of (Architect) Mimar Sinan.

(6) To tell/ write/ mark from the options why the tomb of (Architect) Mimar Sinan is in Süleymaniye Complex.

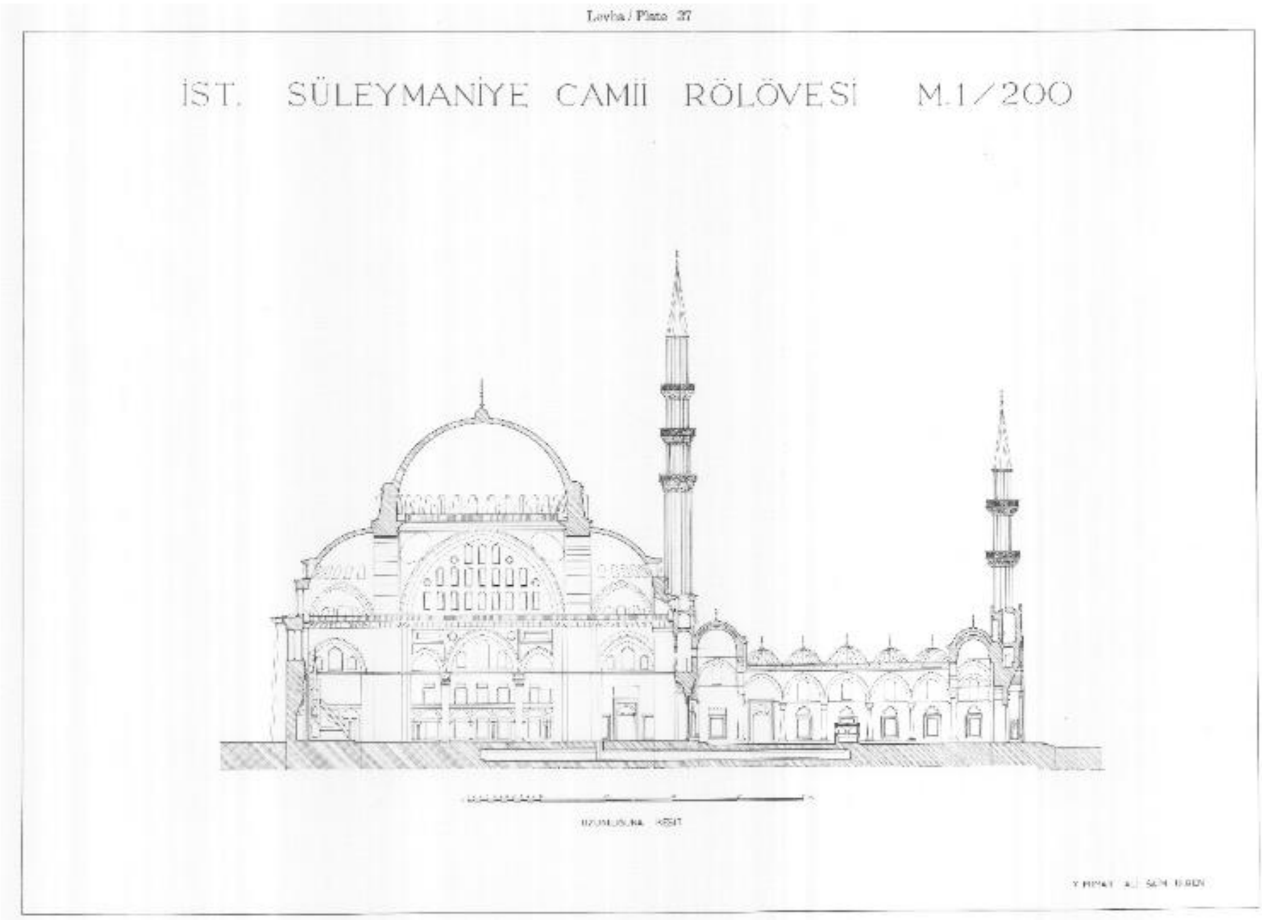
(7) To tell/ write/ mark from the options the most influential factors in the construction of complexes by the Ottoman Empire's Padishahs (Sultans).

C. CREATING DIGITAL ASSETS

The digital assets within the study's scope were produced according to the educational application's needs by adhering to the architectural and material characteristics of a historical complex in the art history course curriculum. The creation of digital assets was a complex process that involved the meticulous reconstruction of the architecture of the building in a three-dimensional digital environment. This process showcases the depth of our research and the level of expertise required in this field. Digitally recreated architectural structures in the virtual world combine three-dimensional model geometries and the model's textures. In this context, the study has proceeded in two directions: generating three-dimensional models and creating texture maps/images.

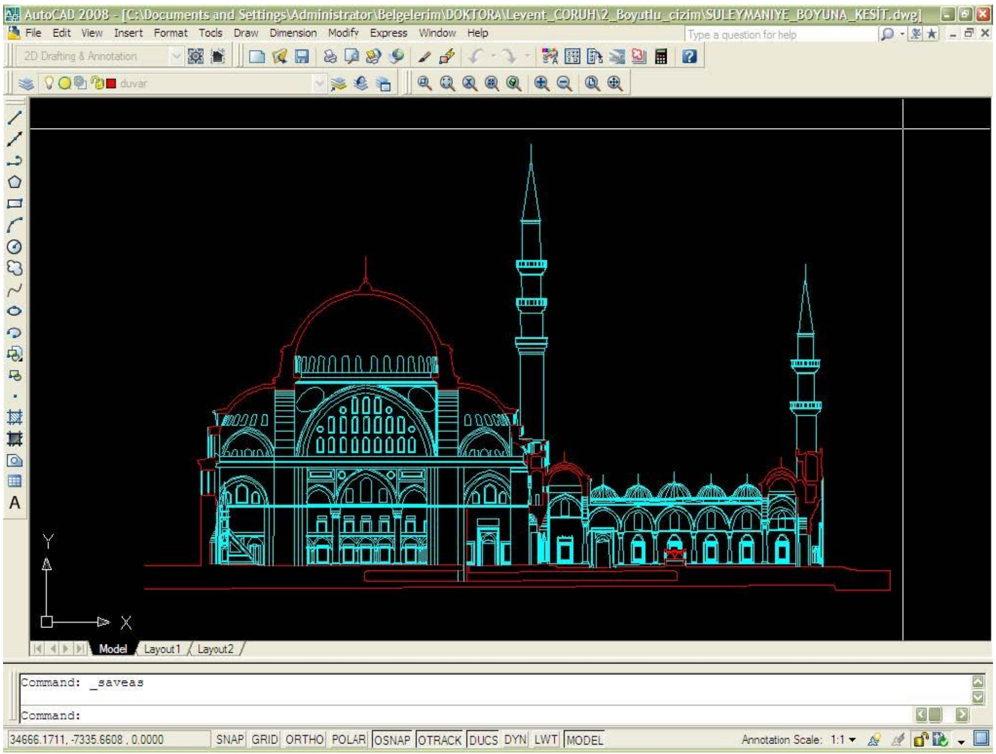
1. Creating the Three-Dimensional Model

To digitally recreate the building's 3D model, we relied on the two-dimensional technical drawings from architect Ali Sami ÜLGEN, which were dated 1945 (Ülgen et al., 1989) (Figure 1). These drawings were elaborately redrawn to scale using AutoCAD software by an architect during the digitization process (Figure 2). In the next stage, the digitized two-dimensional plan, section, and elevation drawings were brought together in the virtual space of the three-dimensional design program (3D Studio MAX). The drawings were superimposed to scale on the correct axes, and scale errors were corrected. This way, a 3D model base was constructed as a wireframe in the virtual environment (Figure 3). Figure 4 demonstrates the subsequent step in the process, which involves creating a three-dimensional model from the model base established in the previous stage. This is achieved by adding depth and volume to the wireframe, resulting in a more realistic representation of the object. Industry-standard structural soundness is a critical factor in the performance of 3D models in real-time virtual environments. Considering its structural soundness, the model was created using 3D Studio MAX's wide range of modelling tools, such as parametric and polygon tools. At this stage, the model was turned solid but lacked colour and surface texture (Figure 5).



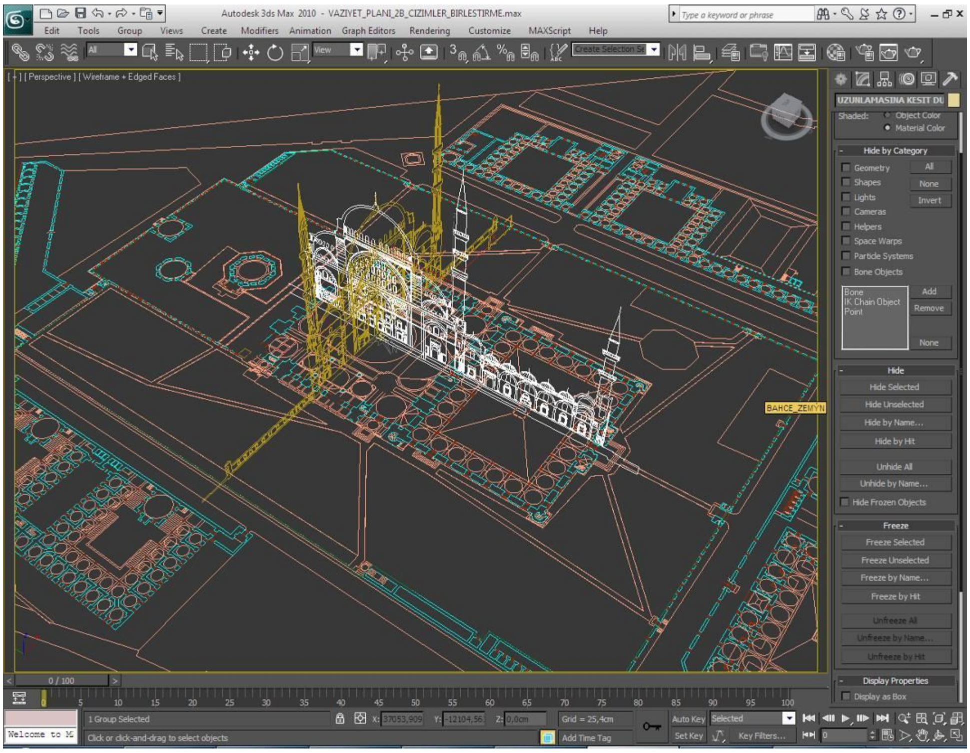
Source: Ülgen et al. (1989)

Figure 1. An Example of 2D Technical Hand Drawings - Cross Section 1945



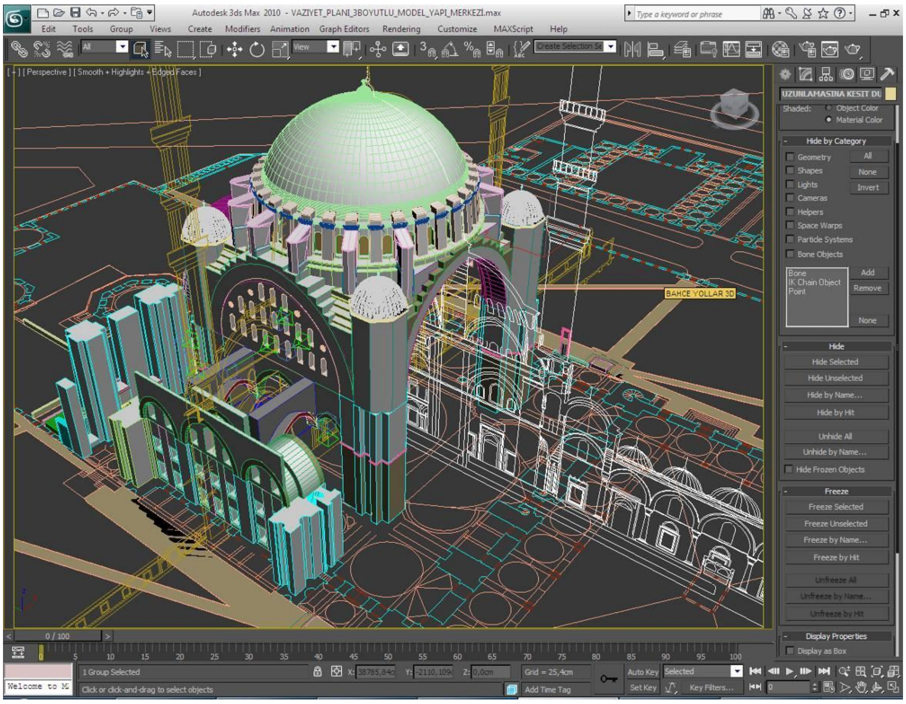
Source: Çoruh (2011)

Figure 2. Two-Dimensional Drawing of Cross Section in Computer Environment by Duygu Ovacık



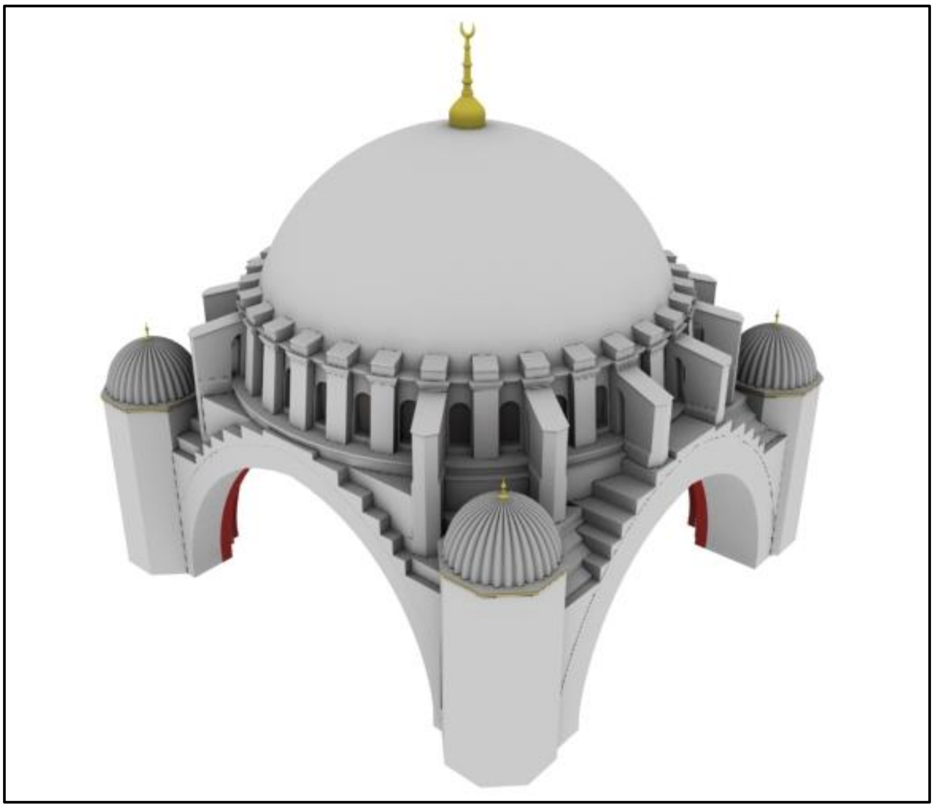
Source: Çoruh (2011)

Figure 3. Creating Model Base in 3D Studio MAX Software by Two-Dimensional Technical Drawings



Source: Çoruh (2011)

Figure 4. Creation of Three-Dimensional Model from Model Base on Technical Drawings



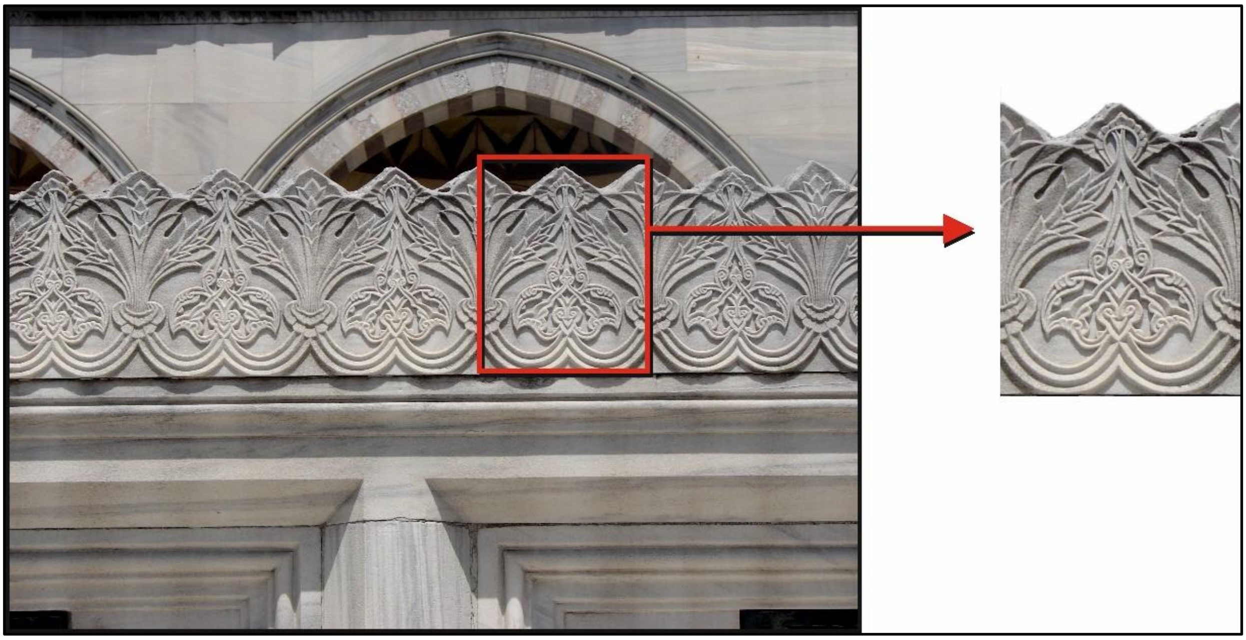
Source: Çoruh (2011)

Figure 5. Completed 3D model showing the main dome and weight towers

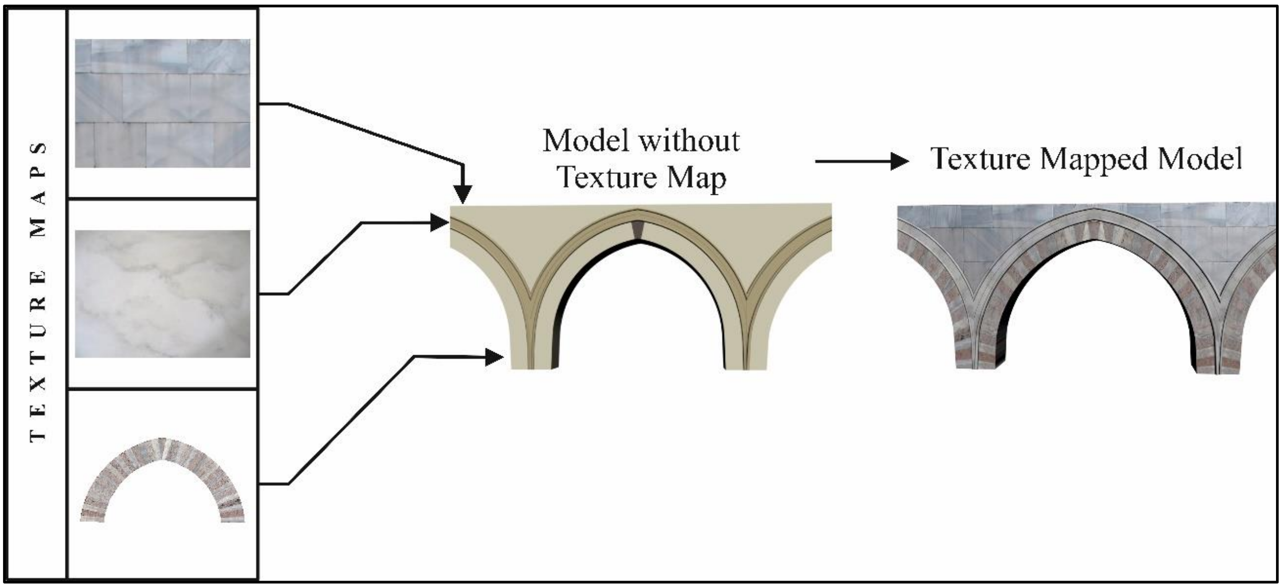
2. Creating the Mapping Textures

After the modelling phase, texture maps were applied to the digital model. Texturing (or texture mapping) is the process of wrapping a two-dimensional texture map around a three-dimensional digital object. As Shiratuddin and Thabet (2002) state, texture mapping can be likened to some extent to wallpapering, painting, or applying a coating to a real object (p.11). As the quality of the photograph from which the texture applied to the three-dimensional model is obtained increases, a more effective and realistic three-dimensional model can be obtained (Duran & Toz, 2002). The mapping textures used in the educational application were obtained by taking high resolution photographs from the building. Corel PHOTOPAINT image processing software was used to convert the image files containing each texture (stone, marble, wood, etc.) and decoration elements (tile, surface decoration, etc.) in the building into the appropriate size, resolution, and shape for the models to be mapped. Figure 6 shows the process of converting the photographs taken into texture materials.

UV coordinates play a crucial role in the precise alignment of two-dimensional images onto three-dimensional geometries. This process ensures that the mapping is free from distortion, enabling accurate texture alignment (Poranne et al., 2017). Advanced UV mapping techniques enhance visual realism by providing specific mappings for various geometric forms such as spheres, cylinders, and planes (Maggiordomo et al., 2021). UV coordinates were created according to the type of model geometries by considering the model's X(U), Y(V) and Z(W) axes in the virtual space. Textures were assigned to the model surfaces according to these coordinates. Figures 7 and 8 show examples of the components of texture-mapped Arches and Fountain models. Figure 9 shows the original Fountain photograph and the digital Fountain model with the texture mapping process completed.

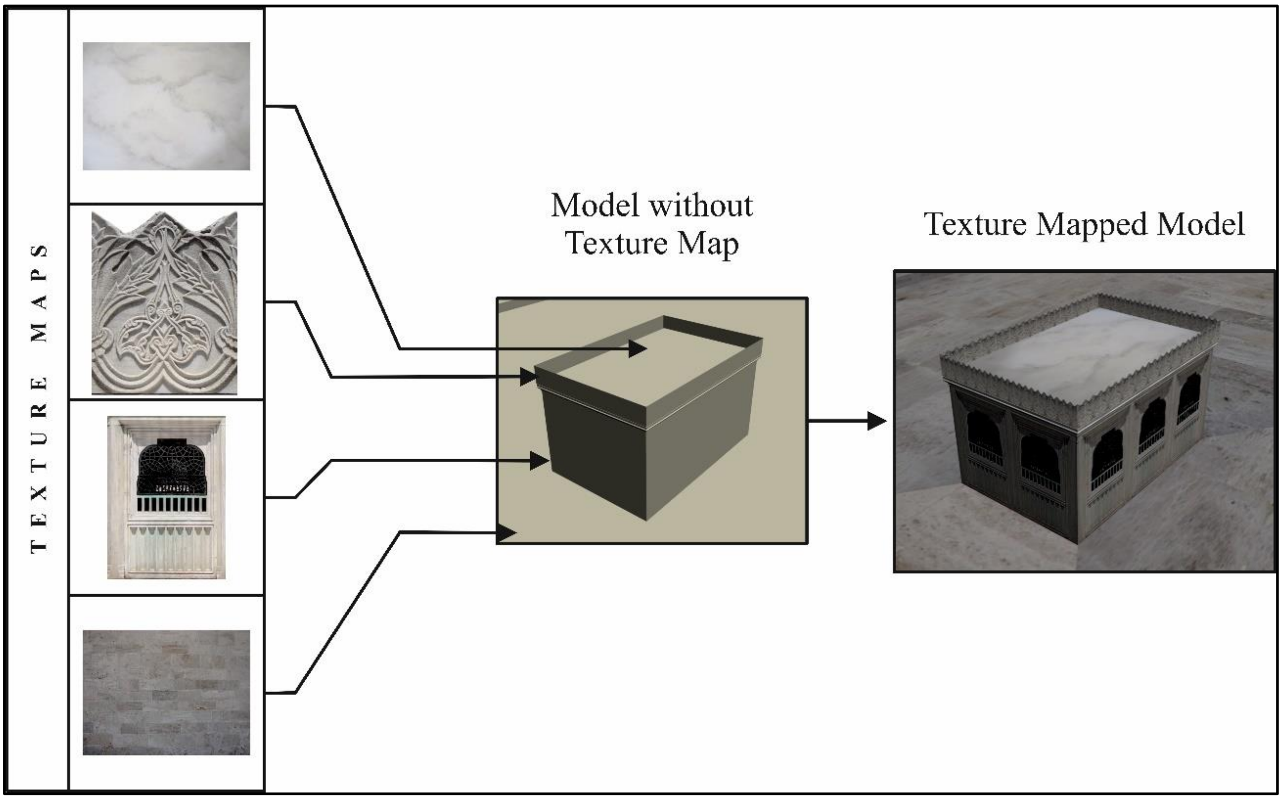


Source: Çoruh (2011)
Figure 6. Extraction of the fountain crown texture from the photograph



Source: Çoruh (2011)

Figure 7. Texture Mapping of Arch Model Textures



Source: Çoruh (2011)

Figure 8. Texture Mapping of the Fountain Model

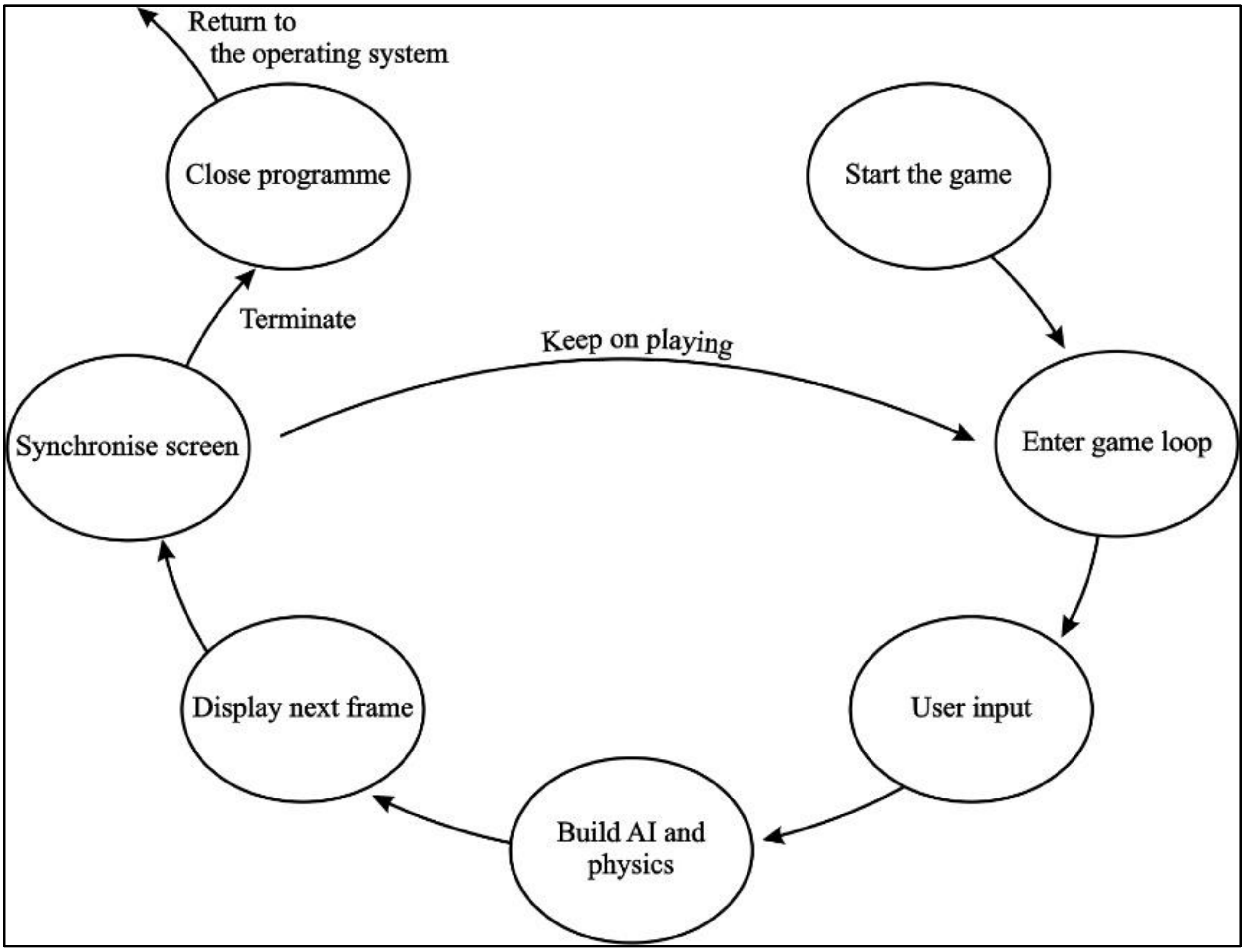
Source: Çoruh (2011)
Figure 9. Fountain Photograph (left), Texture Mapped Digital Fountain Model (right)

D. PROGRAMMING THE GAME ENGINE

1. About the Game Engine

The The development of the game engine involved the use of several key technologies. The DarkBASIC computer programming language and Microsoft DirectX libraries were utilized to transform a three-dimensional model into an interactive training tool suitable for the simulation method. Game engines, including the one developed for this research, are typically created using Microsoft DirectX or OpenGL libraries and can be used in various programming languages such as C++, Java, Delphi, Visual Basic, and DarkBASIC (Efe, 2007, p. 71). A computer program, specifically designed for the pilot application of this research, was instrumental in adding interactivity to the digital model. The computer program developed for this research is known as a Game Engine or Three-Dimensional Engine. Similar software has been developed by various software companies and is used today for many three-dimensional presentations and applications, including computer games, military and scientific studies, and archaeological studies. Game engines contain ready-made libraries and editors to shorten the production process (Akay, 2010, p. 90-91).

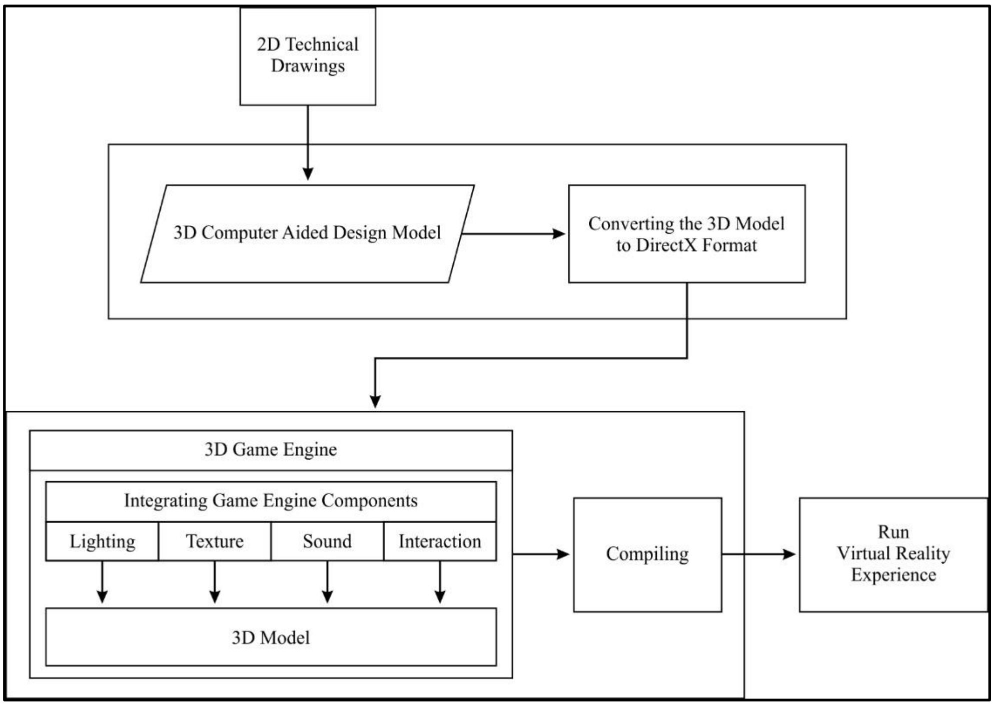
As quoted by Tüzün (2010) from Hearn and Baker (1986), a game engine enables the display of a three-dimensional environment by performing tasks such as representing three-dimensional objects in a certain format and illuminating these objects according to light sources at certain positions. The operating phases of the game engine are given in Figure 10. The Game Engine developed for this research was designed in moderation to fulfil the needs of the educational application. With this game engine, it was possible to define a three-dimensional virtual space which is an imitation of the real world in a digital environment. This practical application allows students to navigate in the desired axes using various input devices such as keyboards, mouses, joysticks, gyroscopes, and accelerometers. The reactions produced by the student through the input devices are transmitted to the computer. In response to these reactions, the game engine redraws the virtual scene images on the screen by making the necessary changes in the scene according to the student's movement. These new images and sounds are transmitted to the student through output devices such as a screen, projector, and VR headset.



Source: Tüzün (2005)
Figure 10. Game Engine Operation Diagram

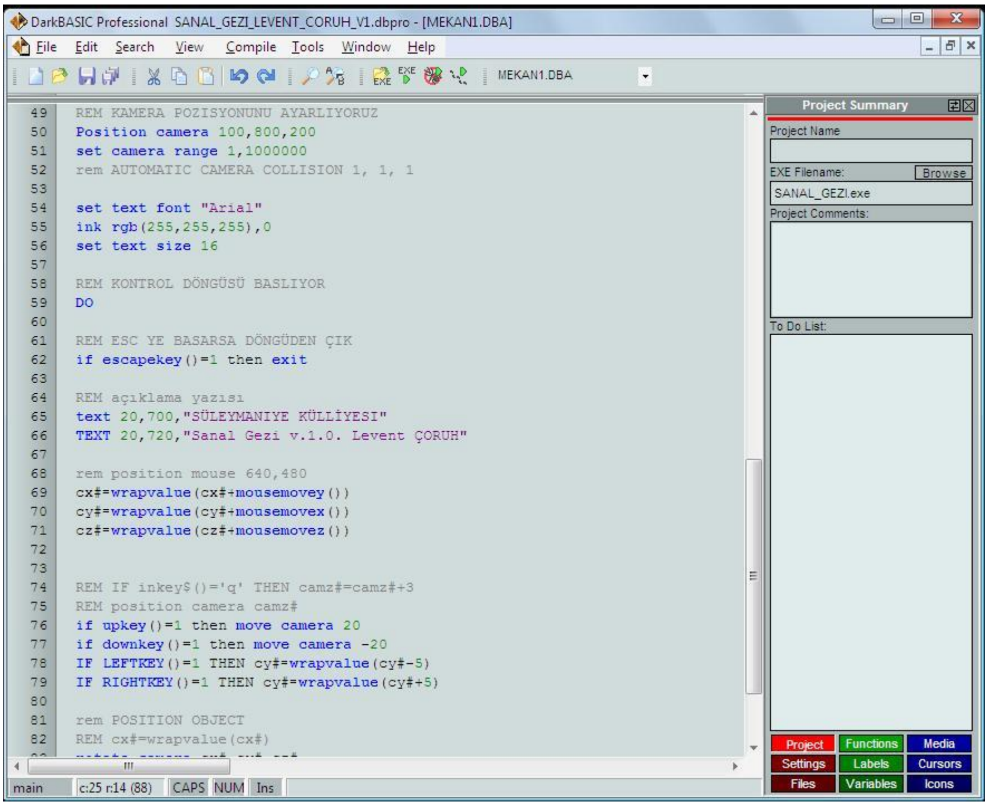
2. Programming of the Application

At this stage, we are actively developing the real-time three-dimensional walk-through application based on the 2D plan, and sectional view drawings, as shown in Figure 11, marking a significant milestone in our project. The game engine developed for the Süleymaniye Complex Virtual Tour application was developed in Dark BASIC programming language. Dark BASIC software development package is designed to develop computer games and three-dimensional applications and supports the file format of many 3D design programs (.3DS, .X, etc.). DarkBASIC code editor and compiler were used for writing and compiling the program code of the Game Engine. Figure 12 shows the screenshot of the DarkBASIC code editor. The game engine is programmed to display the three-dimensional model created on the screen with geometric features and texture mapping. In addition, the user can navigate within the space by using the arrow keys on the keyboard. The objects in the scene are constantly redrawn on the screen in real-time according to the user's new position. The program is designed to refresh the image on the screen 30 times per second. The game engine's program codes are given below.



Source: Çoruh (2011)

Figure 11. Detailed Development Process of the Application



Source: Çoruh (2011)

Figure 12. DarkBASIC Code Editor

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REM CODE INITIALISATION

REM CLEAN AND COLOUR THE SCREEN
Cls 255

REM SET THE SCREEN RESOLUTION AND COLOUR MODE
Set Display Mode 1024,768,32

REM SET THE SCREEN REFRESH RATE
Sync rate 30 Sync On

REM LOADING OBJECTS (MODELS)
LOAD OBJECT "walls.x",1
LOAD OBJECT "main_dome.x",2
LOAD OBJECT "courtyard_domes.x",3
LOAD OBJECT "pillars.x",4
LOAD OBJECT "courtyard_pillars.x",5
LOAD OBJECT "walkways.x",6
LOAD OBJECT "minaret_1.x",7
LOAD OBJECT "minaret_2.x",8
LOAD OBJECT "minaret_3.x",9
LOAD OBJECT "minaret_4.x",10
.
(All objects are loaded in the same way.).
.
REM SET THE CAMERA POSITION
Position Camera 100,800,200
Set Camera Range 1,1000000

REM FONT SETTINGS
Set Text Font "Arial"
Ink Rgb (255,255,255),0
Set Text Size 16

REM BEGINNING OF CONTROL LOOP
Do

REM EXIT THE LOOP IF ESC IS PRESSED
if escapekey()=1 then exit

REM DISCLOSURE TEXT
Text 20,700,"SÜLEYMANİYE COMPLEX"
Text 20,720,"Virtual Tour Ver.1.0. Levent ÇORUH"

REM SET MOUSE POSITION
cx#=wrapvalue(cx#+mousemovey())
cy#=wrapvalue(cy#+mousemovex())
cz#=wrapvalue(cz#+mousemovez())

REM SET KEY CONTROLS
If Upkey()=1 Then move camera 20
If Downkey()=1 Then move camera -20
If Leftkey()=1 Then cy#=wrapvalue(cy#-5)
If Rightkey()=1 Then cy#=wrapvalue(cy#+5)

REM SET THE OBJECT POSITION
Rotate Camera cx#,cy#,cz#

REM END OF SCREEN REFRESH COMMAND
Sync

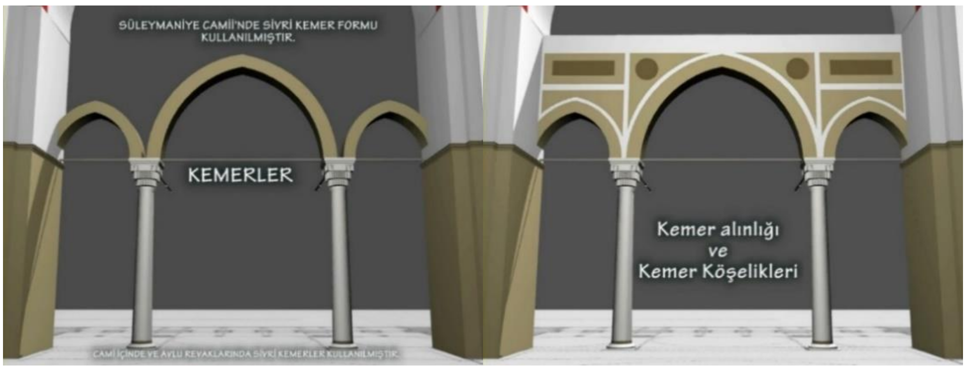
REM END OF LOOP
Loop
```

E. PRODUCTION OF 3D ANIMATIONS

The animated narrative is primarily designed to educate and enlighten, focusing on presenting the structure, aesthetic features, and functional aspects of architectural elements. These elements are carefully aligned with the objectives of Core Competence 1, ensuring a comprehensive understanding of the subject matter. 3D digital models were meticulously overlaid during animation production onto Architect Ali Sami Ülgen's original two-dimensional hand drawings. This intricate technique ensures that the building elements appear in their exact positions on the plan, mirroring the order of their real-world construction. The animation vividly demonstrates how each element is intricately connected to the preceding one. As the building elements seamlessly blend into the scene, the name and function of each element are displayed on the screen as text and remain visible until the introduction of the next element. The animation culminates after the entire building is digitally constructed as a three-dimensional model on the plan. We created the animation using 3D building models designed for virtual reality applications. We developed the animations in the 3D Studio Max design and animation software within a three-dimensional space and then produced videos. After converting the animations into videos, we added text at specific points on timeline using Adobe Premiere video editing software. Figures 13-19 show sample frames from the animation.

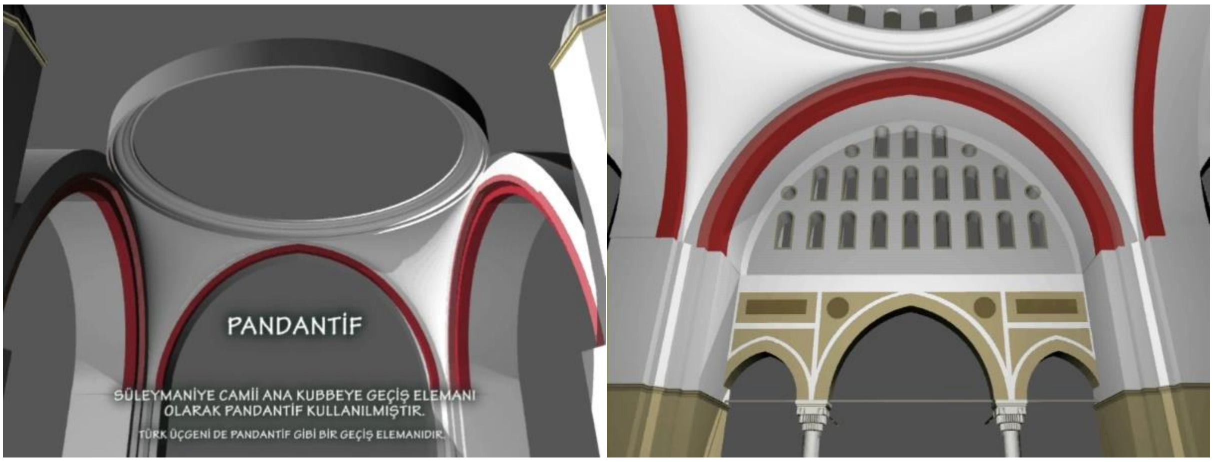
Source: Çoruh (2011)

Figure 13. Animation frames: Mucarnassed column heads and tension bars preventing the arches from opening



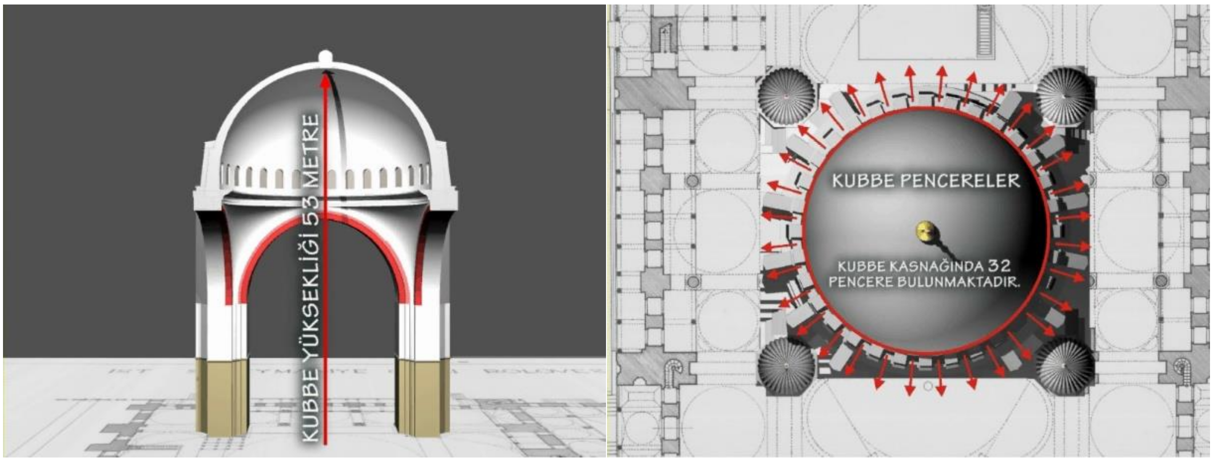
Source: Çoruh (2011)

Figure 14. Animation frames: arch form, arch pediment and arch corners.



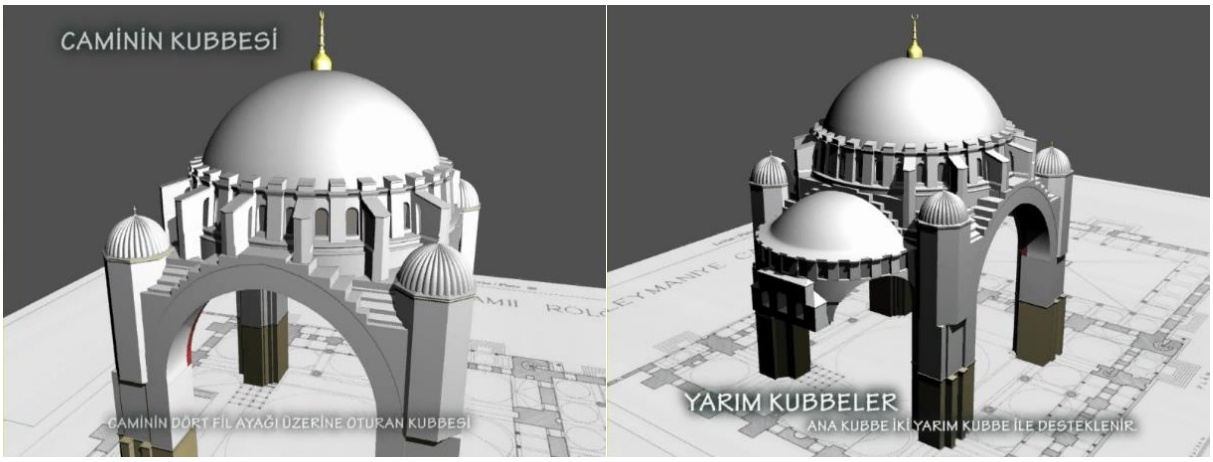
Source: Çoruh (2011)

Figure 15. Animation frames: Pendentives (transition element to the dome)



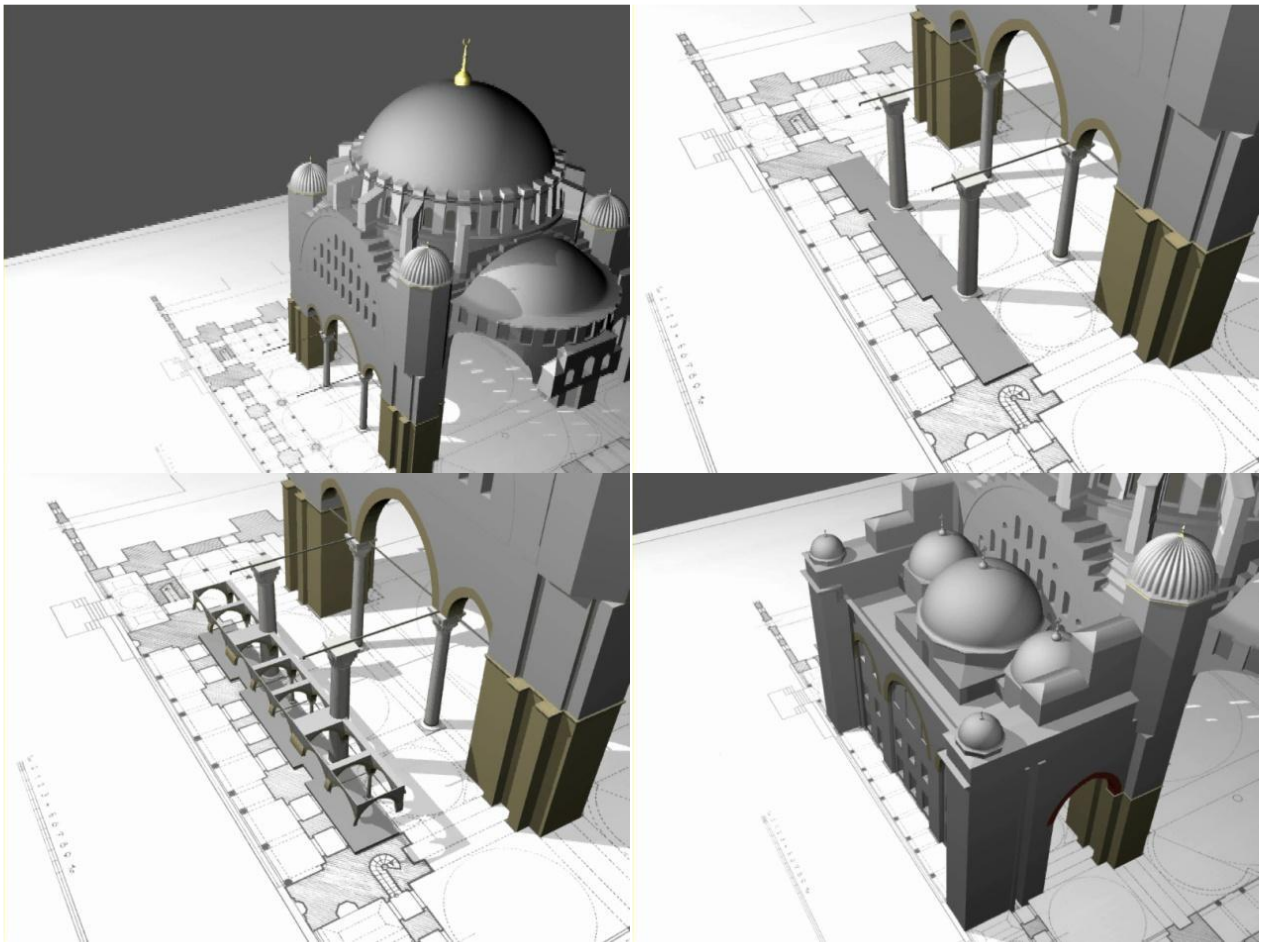
Source: Çoruh (2011)

Figure 16. Animation frames: main dome and its skylights



Source: Çoruh (2011)

Figure 17. Animation frames: dome and half domes of the mosque



Source: Çoruh (2011)

Figure 18. Animation frames: Placement of architectural elements in the building

Source: Çoruh (2011)

Figure 19. Sample animation frames from interior animation

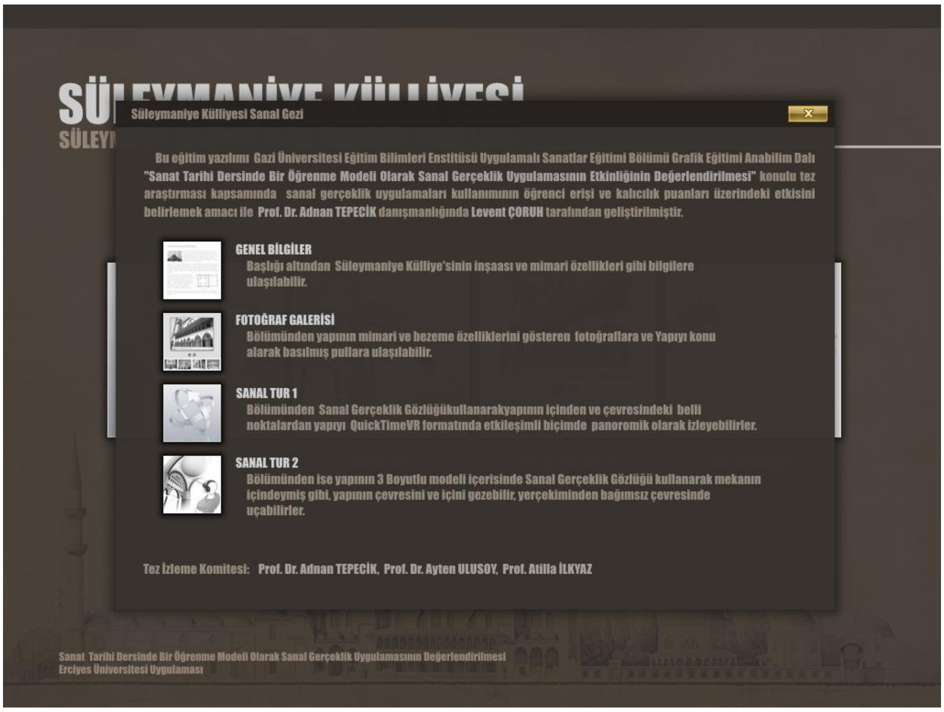
F. INTERFACE DESIGN

1. Graphic Design and Interaction Design of the Interface

The training interface will be the first screen the student will encounter while transferring the targeted information to the student. Therefore, this screen should be categorized according to its purpose and contain correct and easy-to-understand instructions. With this in mind, the interactive software interface should be meticulously designed to present information about the selected subject in the most optimal manner, thereby enhancing the student's learning experience. For a more effective teaching-learning process, instead of haphazardly organizing multimedia components, it is necessary to consider design principles for audio and visual elements suitable for teaching, research on the development of these environments, and principles related to multimedia interface design (Rogers, 2001). Franzwa (1973) emphasizes that, in accordance with these aims and principles, it is crucial to design understandable, clear, and useful interfaces suitable for students' limited cognitive capacities. If there is an information overload on the page in an interface that is not designed successfully, the user may not know where he/she is in the flow and may get lost.

If the interface design is not intuitive, has an unclear layout, and presents difficult navigation, the extrinsic cognitive load, as explained by Cognitive Load Theory (CLT), may increase (Sulisworo et al., 2024). Cognitive load refers to the volume of information that can be retained in working memory concurrently (Juliano et al., 2022). Excessive cognitive load can negatively affect learning and student motivation. CLT divides the cognitive loads in individuals' working memory in learning processes into three main groups: Intrinsic Cognitive Loads, Extraneous Cognitive Loads and Germane Cognitive Loads (Sweller et al., 2019; Armougum et al., 2019). Intrinsic cognitive load refers to the load caused by the intensity of the material presented or the level of complexity of the information. Germane cognitive load refers to the working memory load required to cope with intrinsic loads and is directly related to the amount of intrinsic load (Sweller et al., 2019). Our influence on Intrinsic and Germane loads is limited to optimising Intrinsic loads and making space for Germane cognitive loads from Extrinsic loads. On the other hand, the way information is presented through technology is related to the external load, which can be reduced with the proper approaches. With this feeling, we have paid attention to the user-friendly interface design in a way that will provide students with easy access to information and will not create unnecessary external load.

Macromedia Director software was used to design the interactive training interface needed for the research. Pre-made interactive panoramic images (Süleymaniye Mosque 360 Panorama | 360Cities, n.d.), a 3D model integrated with the game engine, photographs of the structure, general information, animation, and narration were brought together under one interface. The educational software was compiled in a workable form on CD-ROM and made ready for pilot application. In the interactive training software interface, there are four main headings, including certain sections. In the opening screen, there is an introduction window aiming to give preliminary information to the students about these sections and the purpose of the research. The sections on the main menu screen of the training interface shown in Figures 20 and 21 can be listed as follows: Virtual Tour 1, Virtual Tour 2, Photo Gallery, and General Information.



Source: Çoruh (2011)

Figure 20. Educational Software Information Screen

Source: Çoruh (2011)

Figure 21. Educational Software Main Menu Screen

2. Virtual Tour 1

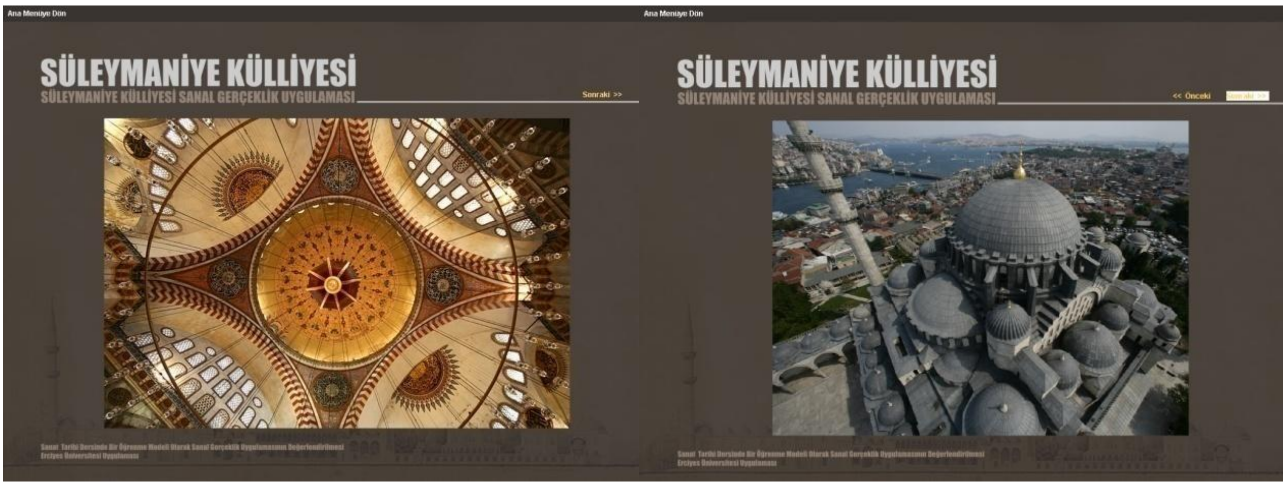
In this section, students can use virtual reality glasses, a keyboard, and a mouse to watch the details of the building with panoramic images taken from 360-degree angles from certain points inside and around the building and made interactive with Quicktime VR technology (Figure 22).

Source: Çoruh (2011)

Figure 22. a) Map showing the location of panoramic cameras on the site plan of the building complex. b) View of the building from the camera's point of view in the mosque courtyard (Süleymaniye Camii iç avlusu | 360Cities, n.d.).

3. Photo Gallery

In this section, there are photographs showing the architectural and decorative features of the building and printed stamps about the building (Figure 23).

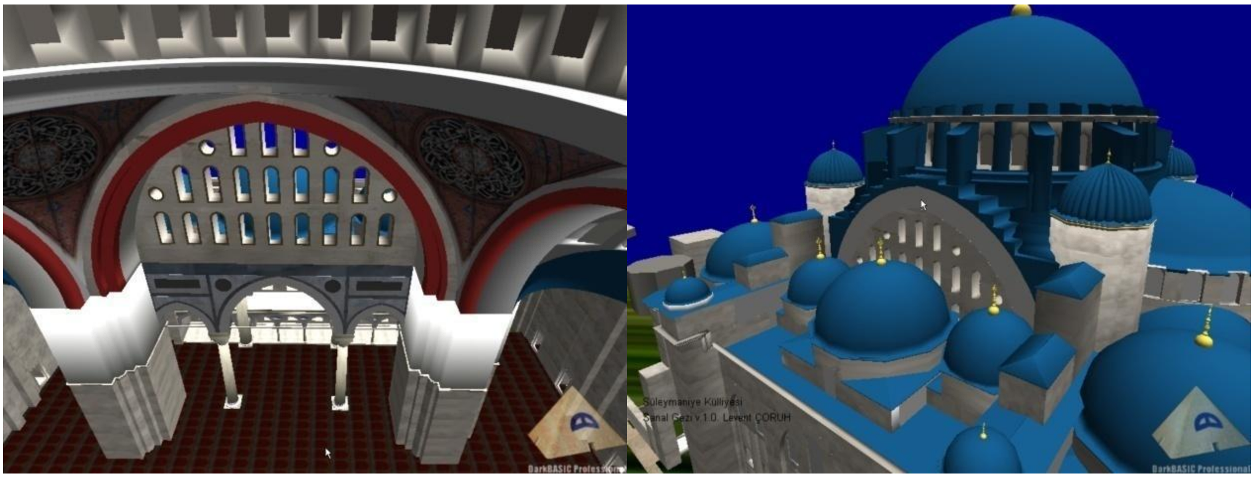


Source: Çoruh (2011)

Figure 23. Screenshots from the Photo Gallery Section

4. Virtual Tour 2

In this section, students can walk around and inside the building by using virtual reality glasses, a keyboard, and a mouse in the 3D model of the building as a walkthrough. They can fly around the building independent of gravity and pass through the walls. Interaction with the game engine programmed in DarkBASIC language was added to the three-dimensional model of the building used in this section (Figure 24 and Figure 25).



Source: Çoruh (2011)
Figure 24. 3D Interactive Model Screenshots Integrated with Game Engine

Source: Çoruh (2011)
Figure 25. 3D Interactive Model Screenshots Integrated with Game Engine

5. General Information

In this section, information such as the construction and architectural features of the Süleymaniye Complex can be accessed (Figure 26).

Source: Çoruh (2011)
Figure 26. Screenshots from the General Information Section

6. Narration by Animation

Apart from the four main sections on the main menu screen, there are *About Software*, *Animated Narration*, and *Exit* options at the top of the screen. When the *About Software* option is selected, the information window on the start screen is displayed again. When the Animated Narration option is selected, a three-dimensional text-supported animation starts to be played, in which the architectural elements of the building and their placement relative to each other are introduced from the base to the dome, as required by the training objectives (Figure 13-19).

Conclusion and Discussion

The research endeavours to develop a new educational material that integrates various rich media, including virtual reality, animation, textual information, and 360° panoramic photographs, into a coherent structure. The specific focus of the educational material is a course unit from the undergraduate Art History curriculum, centering on the Süleymaniye Complex, a significant work of Mimar Sinan in Ottoman Religious Architecture. The competencies to be addressed within the educational material have been determined by experts in art history and architectural history, and experts in educational sciences and graphic design have established the methods for delivering these competencies using digital tools. Following extensive discussions, it was determined that different types of visual materials would be combined under a unified interface. Two of these visual materials make use of VR technologies. One involves a walk-through software offering the highest level of interaction with six degrees of freedom. The other utilizes panoramas based on photo-realistic Quicktime VR technology with three degrees of freedom from specific locations. Additionally, three-dimensional animated narratives have been incorporated to elucidate the functions of the building's structural elements, their relationships, and the architectural creation of space. The interface also encompasses photographs of the general structure and details of the building, along with texts containing historical and general information about the building. Upon the conclusion of the development phase, a preliminary assessment of the educational material was conducted. In a classroom environment equipped with VR technologies, computers, and projection, a lesson on the relevant unit was delivered to a small group of lecturers(2), research assistants(2), and students(4). Subsequently, the participants' reflections were gathered through focus group interviews. In their opinions, the participants stated that the educational material provides a real-life-like experience, visual richness and interaction that engages the students, and in this way, it is capable of significantly increasing the level of interest and continuity of interest among students. Based on participant feedback, we conclude that the educational material has a high potential to have a positive impact on learning achievement and retention. This research focused on material development and was completed by conducting a preliminary evaluation. In addition, the effectiveness of this educational material was later evaluated with an experimental application, and the results were published by Çoruh and Tepecik (2010)[1]. The results supported the preliminary evaluation results in terms of the effect of the material on learning achievement and retention scores.

The results we reached regarding the instructional design development processes, which is the focus of the study, are as follows. As a result of the experience and findings on instructional design through the study, two issues came to the fore: interdisciplinary collaboration and the presentation of content with a holistic perspective of different media types. As the first of these topics, it was emphasized that successful instructional material should be designed multi-layered. These layers consist of education, design (visual / interaction / animation) and information technology disciplines. We concluded that the construction of this structure is possible through the collaboration of discipline-specific experts with the course instructor. Secondly, this collaboration includes various specializations for tasks such as determining the pedagogical approach, content creation, interface graphic design, interaction design, animation production, and adaptation of innovative digital technology such as Virtual Reality (VR) / Augmented Reality (AR) / Mixed Reality (MR) / QuickTime VR. However, it still requires shared authorship for the interest of these experts in a specific outcome.

Ethics Committee Consent

The authors declare that this study does not contain any studies with human participants and/or animals performed by any authors.

Contribution Rate Declaration

The authors declare that they have contributed equally to the article.

Conflict of Interest

The authors of this publication declare they have no conflict of interest.

[1] Coruh and Tepecik (2010) conducted a study with 50 students using an experimental-control group. They discovered that using VR resulted in approximately 15% higher learning achievement and 27% higher learning retention compared to the traditional method. For more information, you can visit https://www.iet-c.net/publication_folder/ietc/ietc2010-3.pdf.

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