A 4D ANIMATION SUPPORTED STROYTELLING PRESENTATION TECHNIQUE TO BETTER UNDERSTAND THE TECTONICS OF ARCHITECTURE BY USE OF A GAMING PLATFORM

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ABSTRACT

A 4D ANIMATION SUPPORTED STROYTELLING PRESENTATION TECHNIQUE TO BETTER UNDERSTAND THE TECTONICS OF ARCHITECTURE BY USE OF A GAMING PLATFORM

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With the developments of technology in architecture, architectural presentation techniques have been developed rapidly. Recently, there has been a tendency to shift from photographic presentation to animated and storytelling ones since these presentation methods give opportunity for more effective transfer of technical information. Moreover, architectural animation can be used as an effective tool to understand the development process of materialization and tectonics of architectural works.

With the addition of interaction to cinematographic explanations, this presentation technique might evolve to be a helpful gaming platform for architecture and construction related people from any level of interest. This method offers more interactive discoveries instead of passive learning techniques, so users might explore different problems and solutions using virtual environments to have beforehand experience on design tasks.

This study aims to create a methodological framework for a 4D animation supported cinematic gaming platform to enrich architectural presentations in a virtual environment and objectify the materialization process of the tectonics of a building.

By the help of interaction, time and motion factors, this method will act like a storyteller of architecture.

As a methodology of the thesis, Hüsrev Paşa Mosque designed by Mimar Sinan will be studied as a case study to examine the capability of this method to disclose the tectonic properties of the selected building. It can be claimed that this method may contribute not only to architectural practice and presentation but also education of architecture by increasing awareness about tectonics and construction methods as well as historical knowledge about architectural works.

Keywords: Animation, Tectonics, Storytelling, Gaming Platform, Process of Materialization

ÖZ

MİMARLIKTA TEKTONİĞİN BİR OYUN PLATFORMU VASITASIYLA DAHA İYİ ANLAŞILMASINI SAĞLAYACAK VE 4B ANİMASYONLARLA DESTEKLENMİŞ HİKAYECİ BİR SUNUM TEKNİĞİ

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Mimarlık alanındaki teknolojik gelişmelerle birlikte mimari sunum teknikleri de hızlı bir şekilde gelişmeye devam etmektedir. Son dönemlerde daha etkili mimari sunumlar yapmak amacıyla fotoğrafik sunumlar yerine canlandırılmış ve hikâye anlatıcı sunum tekniklerine doğru bir geçiş eğilimi görülmektedir. Canlandırılmış sunum tekniği daha etkili bir iletişim kurmaya, teknik bilgilerin, maddeleştirme ve konsept oluşumların daha iyi aktarılmasına fırsat verir. İletişimdeki iyileştirmelere ek olarak, mimari animasyonlar mimari eserlerin maddeleştirme sürecinin gelişimini ve mimari yapıların tektoniğini daha iyi anlamak için de etkili bir araç olarak kullanılabilir.

Sinematografik anlatımlara karşılıklı etkileşimin eklenmesiyle birlikte bu sunum tekniği, mimarlık ve inşaat gibi alanlarla bağlantılı kişilere yardımcı olabilecek bir oyun platformuna evirilebilir. Bu metot pasif öğrenme teknikleri yerine daha çok karşılıklı etkileşime bağlı buluş ve keşifler sunmaktadır. Kullanıcılar sanal ortamlarda farklı problemler ve çözümleri deneyimleyerek tasarım problemleri hakkında önceden kazanılmış deneyim sahibi olabilir.

Bu çalışma sanal ortamlarda mimari sunum tekniklerini zenginleştirmek ve mimari animasyonları daha anlatıcı ve sinematografik bir şekilde kullanarak yapı tektoniğini ve maddeleştirme sürecini somutlaştırmak için 4 boyutlu animasyonlarla desteklenmiş bir sinematik oyun platformu konsepti üretmeyi amaçlamaktadır.

Bu platform ve animasyonlar; karşılıklı etkileşim, zaman ve hareket faktörlerinin de yardımıyla mimarlığın hikâye anlatıcısı olacaktır. Çalışmanın metodolojisinde Mimar Sinan`ın eserlerinden olan Hüsrev Paşa Camii üzerinde bir örnek çalışma yapılarak, üretilen metodun seçilmiş örnek yapıların tektonik özelliklerini ortaya çıkarmak için kullanılabilirliği sorgulanmaktır. Bu çalışmanın son ürününün etkili kullanımının sadece mimarlık pratiği ve sunum tekniklerine değil, aynı zamanda yapı tektoniği ve mimari yapı teknikleri üzerindeki farkındalığı artırarak ve mimari eserlerin tarihi bilgilerinin aktarımını kolaylaştırarak mimarlık eğitimine de faydalı olacağı savunulabilir.

Anahtar Kelimeler: Animasyon, Tektonik, Hikaye Anlatıcı, Oyun Platformu, Maddeleştirme Süreci

To Infinity and Beyond

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LIST OF ABBREVIATIONS

ABBREVIATIONS	
2D	Two Dimensional
3D	Three Dimensional
4D	Four Dimensional
CAD	Computer Aided Design
AEC	Architecture, Engineering and Construction
VE	Virtual Environment
VR	Virtual Reality
AR	Augmented Reality
MR	Mixed Reality

CHAPTER 1

INTRODUCTION

Since stories trigger active imagination that makes experience development more enjoyable and keeps user motivated through comprehensive interactions, storytelling has always been an essential part not only for many disciplines of entertainment industry like music, cinema and games, but also in many occasions in people's everyday lives; communicating with people around, telling them what happened at daily life or talking about future plans is actually storytelling. Like people to people communication, communication of tectonics in architecture needs storytelling for an eloquent transfer of information between the experiencer and product of architecture. Development of usable technology in architecture allows architects to make the presentation of their products more attractive to a variety of people related with architecture, engineering and construction (AEC) industries. Influenced by new representation techniques, it is easy to see a shift in the presentation of architectural products providing opportunity to participate in the story represented in virtual environments for better experience development and knowledge construction.

Design is generally evaluated by its outcome and there might be different evaluation criteria might in different domains. No matter what, creativity in design is always an important criterion together with aesthetics, usability, practicability, functionality and performance which are essentials of tectonic understanding (Kan & Gero, 2017). Tectonic process might be described as the process that develops parts-to-whole relationships between architectural elements as a derivative form of structuring (Oxman & Oxman, 2010). As Han Tümertekin criticizes that, while architectural stage is occupied by unrealistic conceptual designs with imaginary 3D renderings and fly-throughs in which the whole space is narrated flawless, it is important nowadays to mention and discuss tectonics which forms the fundamentals of architecture.

(Tümertekin, 2016, 0:10) Also, Kendir Beraha argues that architectural environment is saturated with 3d visuals, but the backstage of architecture is not discussed, and architecture is perceived as nothing more than image, that situation leads to imitation copy-paste buildings. (Kendir Beraha, 2016, 2:50) Since in many similar cases where architectural works in built environment are perceived as consumable items, presented visuals might be satisfactory. On the other hand, after construction period, perception of satisfaction and priorities of users change correspondingly with life flow and experiences become more important in time. In order to avoid any misunderstanding, it should be stated that the term flawless representations criticized are the ones specific to unrealistic visions of today's mass-production built environment. Otherwise, more realistic and delightful images are always desired to demonstrate to converge virtual and real environments.

Many similar presentations are not representing the experiences that end product will offer but reflect perfect imageries. That might be named as, to put it mildly, a very limited and inexact use of technological developments in architecture that a large part of architects in the market does and unfortunately corroborates that concern. At this point not to shadow developments, it can be said that architectural visualization has been transformed into a new field of profession between architecture and advertising, this issue is mentioned in further chapters.

Moreover, as Csikszentmihalyi states that to encourage someone to make accomplishments, the desired state of mind is Flow state that keeps the user away from getting bored or frustrated and brings happiness during experience (Csikszentmihalyi, 2008). Today, that flow state, which might also be related with immersion, is reached together with the increasing use of game mechanics and game development tools in other fields of activity as gamification and serious games. Use of these mechanics enables an optimal experience as flow state presents with the help of motivation, immersion and voluntary activities. (Gamification of Architecture, 2016)

This study aims to use game mechanics with reinforcement of cinematographic and storytelling motion-based 4D animations to clarify the materialization process of tectonics in architecture. With the latest developments in information technologies like immersive systems allowing the use of effective tools as architectural animations and game mechanics together with storytelling mediums, it might become easier to understand the development and materialization processes and tectonics of architectural products. When used properly, this medium of presentation helps architects to circulate their visions more appropriately and encourages imaginative thinking. In addition to ease in the design phase, challenging communication between people related with AEC industries might become easier with these developments. In this study, animated and gamified presentation acts like a storyteller of architecture instead of being a showcase and this storytelling strengthens spatial experience using narrations and dynamic visuals embedded in the created virtual gamified platform.

1.1. Motivation of the Study

Designers express their design ideas using different kind of presentation techniques. In addition to that, end products of design periods need to be concluded with well-organized presentations that also might be a combination of different presentation techniques. This need for technical and artistic data transfer between designer and the end users requires advancements in presentation techniques and methods for designers, in that case especially for architects, to use to communicate their ideas. With all the developments in the use of information and communication technologies in architecture, many architectural presentation techniques have been emerged day by day. 3D modelling, photographic rendering, *non-photorealistic artistic rendering*, *flythrough and walkthrough animations* are names of few that are used widely today to represent visions of built environments in architecture. Today, together with increasing use of immersive technologies such as virtual reality, augmented reality and mixed reality, there is a tendency for a better presentation set.

With the increasing interest in animations and storytelling approach, scenographic and photographic presentation techniques give their places to animated presentation methods that create opportunity for more effective communication in architecture. This enhancement in the communication makes way for animated presentations to be used as effective tools. This study is motivated by the belief that storytelling and cinematographic animations, when combined with interactive virtual platforms, can provide a medium of presentation that encourages imaginative thinking and helps architects to circulate their visions more appropriately. This motivation has become a pursuit of answer for the question “how can tectonics in architecture be expressed and learned with storytelling applications created using game engines and mechanics?”

1.2. Aim and Arguments of the Study

As presentation techniques evolved in the last few decades, actors from different fields of interest got engaged in architecture. Since they offer more interactive discoveries instead of passive learning techniques, as in many other fields, game mechanics and game related learning methods like serious games and gamification became helpful tools for design, architecture, engineering and construction related people. In addition, architecture is transforming in a revolutionary way and material practices are revitalizing (Oxman & Oxman, 2010). Together with that positive tendency, if well supported, tectonic understanding might lead architectural environment to create well-crafted buildings which brings well-being for communities (Graf, 2011). Since mediation through digital tools both in concept and production stages arouses interest in architectural tectonics (Oxman, 2012), architects would better be in search for developing better tools.

To create better comprehensive interaction environments, game mechanics might be very useful since they enable users to experience problems, solutions, consequences and reshape future actions correspondingly with these beforehand experiences gained from virtual actions and environments. This beforehand experience makes designers to have a knowledge of details on different subjects and encourages them to think and act differently.

In the light of this information, this study aims to create a new presentation method by the combination of interaction, cinematographic animations and storytelling. A virtual tool that can be categorized as a gaming platform that is enhanced by 4D animations and storytelling elements will be used to achieve experiencing architectural structures and constructions in a virtual environment. This study is in the search of a methodological framework for a virtual gaming platform as mentioned before and design of this tool is questioned throughout the study and the question "how to perceive a structure better in a virtual platform and how to make construction of it compatible with architectural design or materials -or vice versa-?" is tried to be answered.

1.3. Methodology, Boundary and Validity of the Study

As a methodology of this thesis, a methodological framework is created for a 4D animation supported cinematic gaming platform to enrich architectural presentations in a virtual environment and investigate the use of architectural animations in a more cinematographic and explanatory way to objectify the materialization process of the tectonics of a building. This platform makes it possible to have knowledge without time and place boundaries by oneself. Instead of traditional common methods like "flythrough" videos, these platform and animations, by the help of interaction, time and motion factors, will act like a storyteller of architecture. In technical development process of the end product of this study, a time and motion based cinematographic animation program entitled Cinema4D (borrowed with a special request from Maxon webpage as a student copy version) and a cross-platform game engine entitled Unity (a free to use software for non-commercial uses) are going to be used to create a learning environment for Hüsrev Paşa Mosque designed by Mimar Sinan, as a case study. Hüsrev Paşa Mosque as a part of Hüsrev Paşa Külliyesi, an Islamic Ottoman social complex, is located in the old city of Van around Van Castle and it was built by

Hüsrev Paşa The Governor of Van in 1567-68 and gone through two different restoration periods.

End product of this study is a 4D animation supported cinematic gaming platform used as a virtual learning environment to present materialization process and tectonics in architecture. It can be claimed that the effective use of this end product of the study may contribute not only to architectural practice and presentation but also education of architecture by increasing knowledge about tectonics and construction methods as well as preservation of historical data by transferring and storing up representations of architectural works. Conceptual framework used in this study might be developed for future uses as a tool in architecture education and history preservation or an alternative learning tool for architecture history, this study is conducted with the awareness that more specialized in-field studies might be required for each of these cases.

This thesis might be categorized as a technical analytical thesis that aims to objectify the capability of studied presentation method to disclose the tectonic properties of the selected building.

CHAPTER 2

TECHNOLOGICAL DEVELOPMENTS IN ARCHITECTURAL PRESENTATION

> What comes out is not always the same as what goes in. Architecture has nevertheless been thought of as an attempt at maximum preservation in which both meaning, and likeness are transported from idea through drawing to building with minimum loss. (Adams, 1998, p. 181)

Design might be defined as “the cognitive process of generating and manipulating representations involved in solving a design problem within a given context and range of constraints.” (Chrysikou, 2015, pp. 228). Even though designers can create mental images in their minds during the design process, there might be exceptions but in general, majority of architects represent these images in different forms, most commonly as sketches on papers or monitor screens. In this manner, it might be said that creative visual design is a product of dialogue between designer and graphical outputs (Grabska, 2015). This dialogue is a key factor in understanding the constructive power of perception which contains implications for a creative design (Ware, 2008).

Since architects communicate their ideas, concepts and information by different presentation techniques using different representations, all these presentation techniques of architecture have a duty as communicating architect’s vision and information with people from any AEC related discipline. That is because at first concept design is conceived by architects, afterwards that design is structured and materialized as a collaborative work of people from different AEC related fields (Oxman & Oxman, 2010). In the search of new techniques for information transfer with minimum loss of data, technological developments enhanced architectural presentations with the use of virtual environments along with physical representations of real environment such as orthographic, perspective and 3D drawings and physical models.

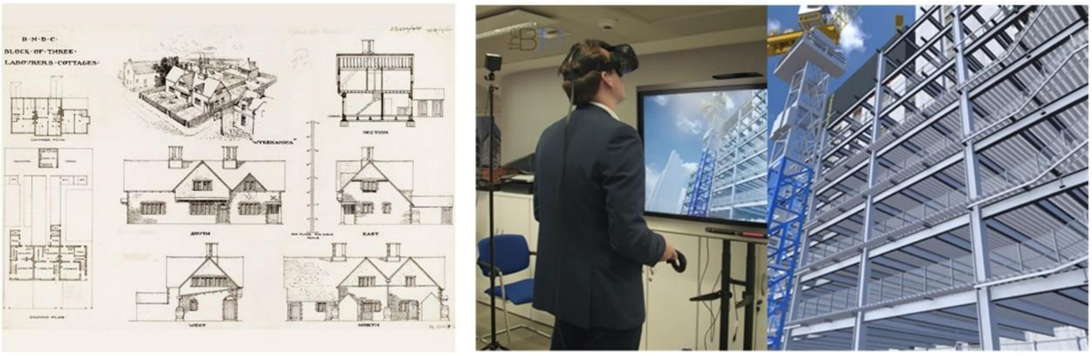

Figure 2.1. **Left:** Traditional orthographic set of a two storey house, **Right:** A real time construction presentation via VR technologies

Source: URL(1), URL(2)

This enhancement attained with the addition of virtual environments to architecture, there were shifts from 2D to 3D and from 3D to 4D, but each of these representation techniques has their own advantages and disadvantages on revealing the information tended to be communicated. With 2D presentation technique including axonometric drawings, orthographic sets, sketches, etc. understanding the tectonics was limited with the imagination of the architect, and communication between architect and client or designers of other disciplines were very challenging. With technological developments in architectural presentation, communication became easier in time with addition of third and fourth dimensions. Even though the fourth dimension is complex in quantum mechanics, it is simply viewed as concerning ‘time’ as in this study. 4D animations and design are helpful terms in differentiating dynamic forms from static 2D and 3D presentations (Robertson, 1995).

As Pete Baxter, Vice President and head of Autodesk UK states, even Egyptian Pyramids needed a set of design and planning to overcome challenges that might have occurred during building the structure. Contrary to popular myths about alien builders, most probable option is that 2D drawings were used communication through design and building processes. Since there is not only one true way for presentation and all techniques can be used consistently at the same time, all together with the new techniques evolved in time such as 3D and 4D technologies, 2D presentations are still used effectively to bridge architecture, engineering and construction (AEC) fields to exchange information between these disciplines. Robertson states that classifying design activities as 2D, 3D and 4D is not an extreme requirement but might be beneficial using these classifications more to identify and highlight different characteristics of design activities (Robertson, 1995). After all one cannot deny that 3D technologies allow architects and designers to express their design and creative vision much easier, and with 4D technologies such as animations and building simulations functionality, performance and behavior of structures can be optimized. (Baxter, 2013)

Figure 2.2. **Left:** Dimension abstraction, **Right:** VR representation of a skyscraper construction

Source: URL(3), URL(4)

2.1. Brief Summary of Developments Related to CAD and 3D Modeling in Architecture

First CAD (Computer Aided Design) systems developed as ancestors of many software today are ‘Pronto’ which was developed by Patrick Hanratty in 1957 and ‘Sketchpad’ announced in 1960 and built in 1963 by Ivan Sutherland both graduate students in Massachusetts Institute of Technology (MIT). (Pyfer, 2017) These programs were able to draw simple lines, move objects on computer screen, and change their dimensions.

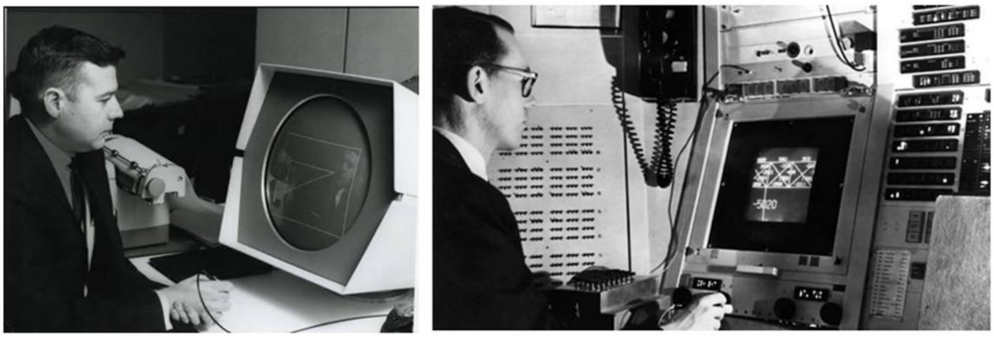

Figure 2.3. **Left:** Pronto CAD System developed by Patrick Hanratty in 1957, **Right:** Sketchpad CAD System announced in 1960 and built in 1963 by Ivan Sutherland

Source: URL(5), URL(6)

Thanks to technological development in production fields of mechanics like car industry, CAD tools were first used decades ago in industrial design. In time starting from 1950s, CAD tools has become a vital tool for designers from any discipline, and this interest made them way more accessible in years with developments of Adam in 1971, CATIA in 1981 and AutoCAD in 1982 ("Timeline of Computer History," n.d.). With each development, designers start to search its availability of use in design processes, and every new technology gives an amount of freedom for designers enhancing their communication of imagery (Hadjri, 2003).

Today, it is not necessary to mention that computer technology advances architecture with every development. Although it was discussed if computers limit architects' creativity in 1990s and 2000s, it is now accepted by almost all designers that these technologies revolutionized the design process. It needs to be mentioned that CAD software are not to be substitute free-hand drawings or physical models but combine with these conventional tools and enhance communication of imagery of designer. CAD software is primarily used for calculating complicated geometries, drawing architectural drawings way faster and producing concept design graphics (Szalapaj, & Chang, 1999).

CAD software were used just for drafting until revolutionary architects like Frank Gehry and Peter Eisenman used them as a design tool in their well-known structures.

Frank Gehry started to use CAD software as a design tool by using CATIA while designing a fish shaped steel structured pavilion El Peix which is an important landmark of Barcelona's seafront (Jencks, 2002). He used CATIA to calculate and analyze this very complex structure hand in hand with physical models, and this innovative attempt enabled manufacturing of this structure. Peter Eisenman's first experience in design phase of a structure was in Aronoff Center in Cincinnati. Gehry and Eisenman's revolutionary attempts created a new kind of interaction between architect and technology (Jencks, 2002).

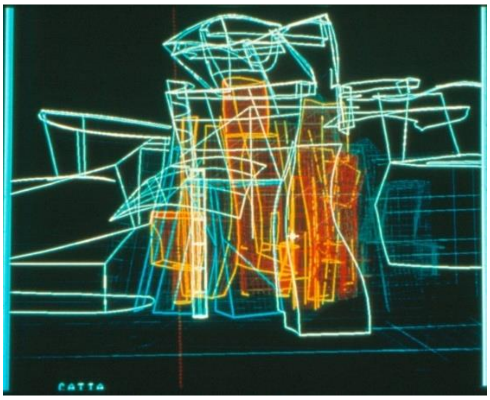

Figure 2.4. CATIA Model of Guggenheim, Bilbao

Source: URL(7)

Developments related with CAD software also corresponded in architecture education and today almost all graduates of architecture are familiar with at least a few CAD software assisting their design and production process. Architecture education mainly aims creating general understanding on fundamentals of problem solving and using this knowledge on built environment. Even if teaching methods are approached from different perspectives in different schools, tools for representing architectural design is similar to each other. CAD tools are added to curriculums in almost every school, and they are used mainly for 2D drawings, 3D models, digitization of design process integrated with free hand sketches and physical models. Today, there are many 3D modelling software used in architecture such as SketchUp, 3DS Max, AutoCAD, CATIA, Revit and Rhino each having different advantages and disadvantages in different subjects. While software like SketchUp are very handy in hard edged object modelling, software like Rhino and 3DSMax are used to create organic forms.

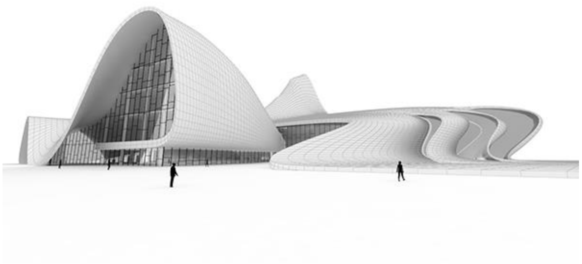

Figure 2.5. Zaha Hadid’s Heydar Aliyev Center modelled in Rhinoceros

Source: URL(8)

Main aim and general use of 3D modelling applications is to draw a physical object in a virtual environment and render them with respect to their material characteristics. 3D modelling can simply be defined as constructing objects in three-dimensional virtual environment with respect to x, y, z coordinates that identify width, length and depth of the object. As users tilt, pan or zoom an interaction occurs between user and object or data space in general As Engeli states that an in-depth knowledge is required to create space related characteristics that is wished to be emphasized by the user and main parameters of 3D models as light, materials and perspective makes user to understand the nature of object and reveal information about it. In addition to that, when manipulated, misinformation of objects might be used to hide many aspects of the modelled object (Engeli, 2000).

Even if this might be the basic definition of 3D modelling, 3D modelling has many other processes and hardly any 3D model ends without being rendered or animated in field of architecture. Three basic factors of 3D modelling that shapes the end product of process can be stated as modelling mode, surface details and lighting. While modelling mode is data about the physical accuracy and abstraction of object being modelled, surface details is data about texture and color assignments, and lastly lighting data is about shading and depth of the object. In addition to that, rendering options as wireframe variations and transparency options are effective illustration tools for analytical object modellings. (Uddin, 2005) Beside all these features of 3D modelling technology, Maldonado expresses that digital models because of their mediating characteristics might also contribute to scientific fields and architecture. He states that 3D models enable users to make tests and experience problems, with these possibilities many different solutions might be tested in a single representation system by making minor changes. (Maldonado, 2015)

Moreover, 3D modelling software it is possible to obtain orthographic sets including plans, sections and elevations. In addition to that other significant representative drawings for form and space perception like axonometric and perspective drawings can be obtained and used to better communicate design ideas. CAD software built up over time and instead of producing repetitive architectural end products, architects were allowed to build complex building details and this freedom brought new types of design productions like biomorphic and organic architecture. Revolutionary architects as Zaha Hadid, Cecil Balmond, Rem Koolhaas, Oscar Niemeyer used latest technologies both in design and presentation of their works. As Ole Bouman states in his article "Amor(f)al Architecture or Architectural Multiples in the Post-Humanist Age", with his passion in form, Greg Lynn used advanced non-architectural animation programs borrowed from different fields of interest such as film industry, to visualize his impressive organic design works (Lynn, 1998). As in this example, many design, computing and visualization software were used interdisciplinary. Beside designing complex structures, producing precise drawings and 3D model making; these tools started to be used to evaluate feasibility and cost of design with additional BIM (Building Information Modelling) features which is not a part of this study except from being a presentation method.

It might be said that use of digital modelling in communication of design ideas when combined with narration might become an explanatory source for presented object, and this source might be used in the creation of a learning environment for people related with different fields of interest.

2.2. A Shift From 3D to 4D Animations and the Use of Motion and Time

People experience architecture in a dynamic way and this dynamism requires motion. As a result of this requirement, architectural animations emerged and started to be used as a representation method in the late nineties. Architectural animations as a tool improved still image representations by addition of time and motion factors which brings the fourth dimension and enables user to better envision the development process of design ideas. On the other hand, creating 4D animations require some complex relations with some tools related with other disciplines as editing and postproduction tools of cinematography or rhythm and harmony tools of music. (Spallone, 2017) 4D design software improve design and team collaboration in design phases, moreover they enable architect to explore and improve project execution strategies. (Gao, Fischer, Tollefsen & Haugen, 2007)

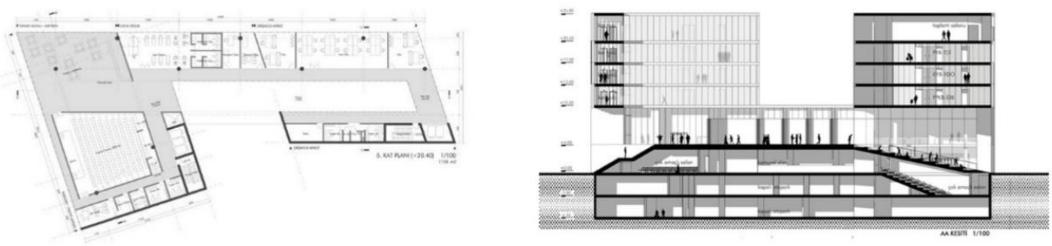

Figure 2.6. 2D plan and section drawings of İZKA competition entry of SCRA

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Figure 2.7. 3D renderings of İZKA competition entry of SCRA

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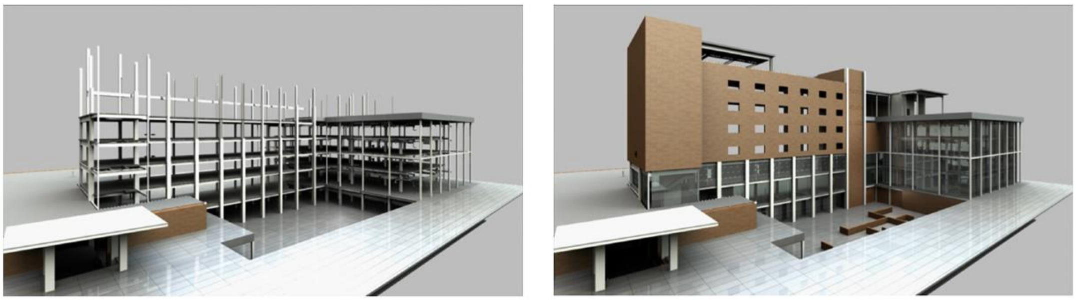

Figure 2.8. 4D construction animation created by Autodesk using Navisworks

Source: URL(10)

Spallone makes a sequential development analysis of architectural animations. First, a singular solid object is centered in the focal point of the scene and a camera view examines the surroundings of that object on predetermined paths which allows user to examine the central object from different angles of view. This first examples of architectural animations were mainly used in conceptual presentations. Second, with the improvement in computer technologies, architectural animations adopted characteristics as photorealism and hyper-realism. This secondary phase of animations was used to create realistic representations of the objects in perfect or sometimes unrealistic living environments. While improvements in rendering systems gave chance to create realistic images, launch of online video sharing platforms as YouTube and video presentations in architectural competitions or exhibitions allowed creators of these animations to promote themselves to public. Third phase was characterized in the search of narrative style that would increase informativity by including dynamic narratives created with a collaboration of architect and video maker. Fourth and the last step of Spallone's sequencing is addition of motion graphics and collocation of static and dynamic images. Animations in this phase uses narrations to express a hybrid of construction and concept phases that is used not only in the communication of conceptual ideas but also demonstrate constructability of the concept. (Spallone, 2017)

After transformations and developments in the use of animation technology, architecture, engineering and construction firms use 4D animations to promote their projects in video presentations mainly seen in architectural competitions, exhibitions and advertisements. Moreover, architectural animations are used for different contexts with different scales in architecture like urban renewal projects, historical preservation projects, landscape projects, infrastructure projects and landmark buildings.

In more recent times, since many architecture firms mastered in the creation and use of architectural animations, these creative firms tend towards interactive application software like real-time visualization tools in the search of new developments for presentation techniques. However, 4D animations are still in a central point of architectural presentations.

2.3. 3D Modeling & 4D Animations by Cinema4D

4D animation software that were designed with the primary aim of creating character animations, fluid diagrams and special effects to be used in different fields of visual media were not thought to be useful in architecture, but they were used in many different ways like rendering, modelling, creating diagrams to explain design formulations. Today these tools are essential for architects since they transformed the design process. (Andia, 2002)

In this study, architectural animations about different construction scenarios will be created using Cinema4D, and each will give explanatory information about distinctive characteristics of the chosen case structure and structural elements. By this way gathered construction information of a case building and its materialization process will be processed to disclose the tectonic properties of each part of the selected building.

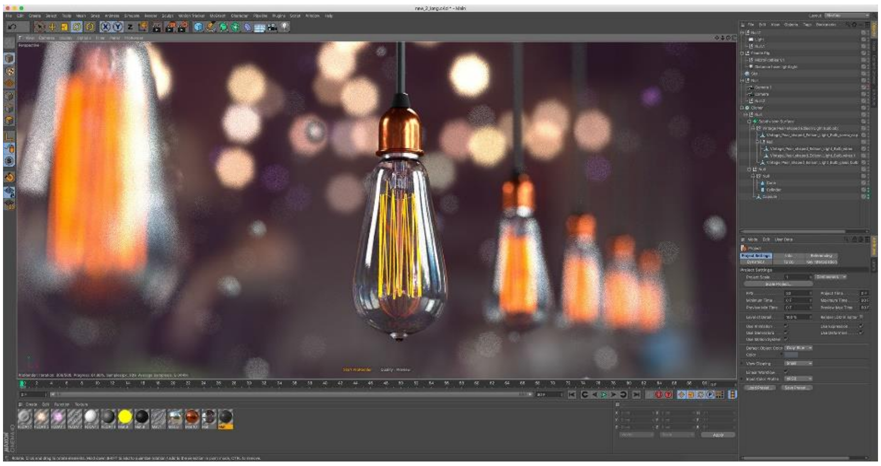

Figure 2.9. Cinema4D user interface

Source: URL(11)

Among similar software like 3dsmax and Maya, Cinema4D was chosen to be used to create architectural animations in this study not only because of the fact that it is a commonly used and preferred visualization software in professional fields, but also because of previous experiences and familiarity of the author from undergraduate works. In addition to that, Maxon supports educational studies with a free to use educational license. Usability of this software will be experienced in this study to create architectural animations.

As a brief summary, Cinema4D is a powerful time and motion based cinematographic animation program used in many fields including architecture. In this study, Cinema4D was borrowed with a special request from Maxon's webpage as a student copy version for educational uses. Today, this software is used commonly in many fields of profession related with visuals such as cinematography, advertising and architectural visualization. Cinema4D will be used in this study for more effective communication of technical information, and to strengthen the comprehensibility of applications and encourage the use of game mechanics and gaming platform created using Unity.

2.4. Real-Time Visualizations

After 4D Animations, a more recent trending topic in architectural visualization is real-time visualizations created using different game engines, most commonly used engines are Unity, Unreal Engine and CryEngine. Also, there are some other software designed using game engines and developed by commercial visualization firms for real-time visualization like Shapespark and Enscape which are used in architectural presentations.

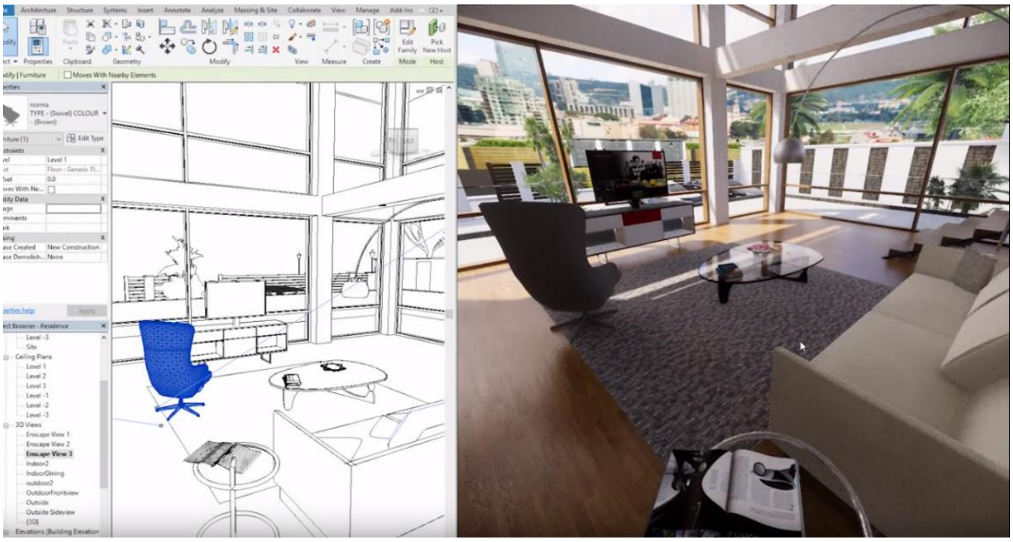

Figure 2.10. Enscape3D interface

Source: URL(12)

Real-time visualizations change the way data is processed, transferred and published. A data stream is processed simultaneously with instant user actions and processed data changes the displayed imagery on user interface (Hanson, 2014). Working principle of real-time visualizations is described as;

> An image appears on the screen, the viewer acts or reacts, and this feedback affects what is generated next. This cycle of reaction and rendering happens at a rapid enough rate that the viewer does not see individual images, but rather becomes immersed in a dynamic process (Akenine-Möller, Haines, Hoffman, Pesce, Iwanicki & Hillaire, 2014, pp. 1).

In real-time visualization, rendered virtual environment can be experienced, preferably with a first-person view, using different medias like a computer screen or VR glasses. Many presentation examples of real-time visualization use interactive elements to make user feel more engaged in created virtual environment like changing color of different objects from a color palette, turning on/off electronic devices or lights.

Figure 2.11. Interactive objects in a presentation created using game engines

Source: URL(13)

2.5. Potentials of 4D Animations, Real-Time Visualizations and Storytelling

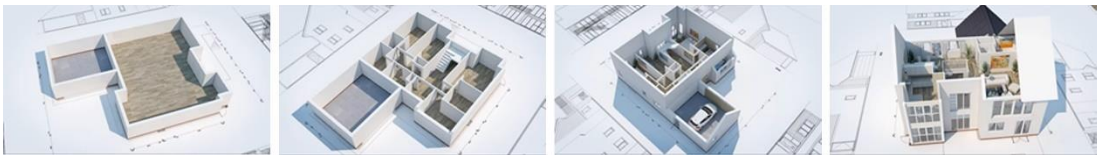

Figure 2.12. “3D House Animation” by Powell Dobson Architects

Source: URL(14)

Architectural animations used in marketing of architecture may be illusive as they are intended to be as a result of marketing strategies. As expected, since they target the end user and main purpose is selling an end product, they are generally not informative about tectonics or materialization process. This kind of animations use scripted imaginary movements in a flawless environment and instead of tectonic elements they highlight trim works of subjected structure. Even if this kind of animations serve their purpose successfully in their courses, they are not used in this study. On the other hand, there can be found software like Synchro and Navisworks that are used to create architectural animations with their 4D tools, but use of these software is mainly related with technical issues of construction phases and more related with building information modelling (BIM).

Figure 2.13. Navisworks splash screen image

Source: URL(15)

Instructive 4D animations in this study are used in examination of tectonic development and materialization processes. Similar animations might be seen in some documentaries as a part of cinematographic explanation. These animations intend to tell a story formation or development of a layered object or incident using technical mechanics like integration, disintegration and layering of both static objects and time periods which creates a more comprehensive environment. When architectural heritage is the subject, historical and material layers are accompanied by immaterial values of environment, structure or community. As places are important parts of everyday life and have meanings for natives, consciously or unconsciously, generations pass knowledge of events or changes happened in these places in different detail levels which is inversely proportional with the time that has passed over these events or changes. On the other hand, collective memory remembers events better if they have interacted directly since these interactions trigger memories and people gets affected by their previous experiences from similar environments when they interact with new ones (Di Mascio, 2015). Since data sources might be destroyed in time because of various reasons, keeping the knowledge of architectural heritage safe for the next generations and crate a source for the stories it is one of the main aims of this study.

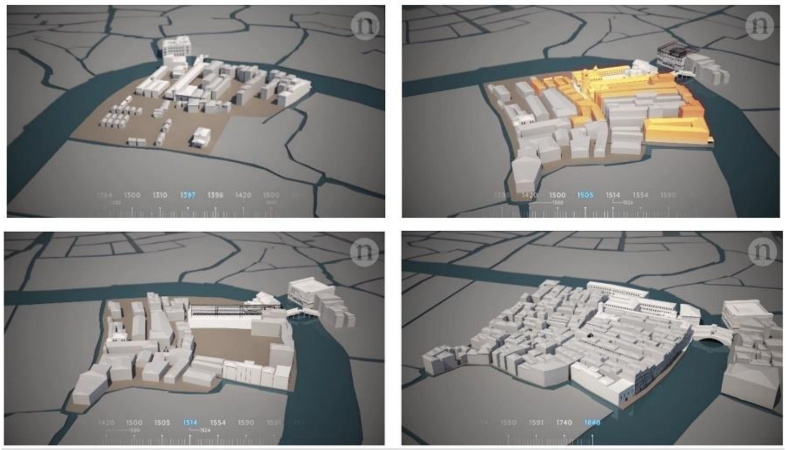

Figure 2.14. Sequential images taken from “A virtual time machine for Venice” documentary

Source: URL(16)

Architectural tectonics which will be investigated in the next chapter is not only about the material survey but also meaning and information survey of the structure. While analyzing the material artefact, complex mesh of immaterial data of that artefact should also be analyzed to relate the structure to a bigger framework of spatial, urban and cultural aspects. Investigation at this point turns into a search for story and presentation of findings, after that this search becomes storytelling (Gantois & Schoonjans, 2015). In addition, architectural built environments are important sources of information since they contain diversity of buildings with different quantities or qualities. These resources of both material and immaterial values should be comprehended, documented and disseminated in a proper way to be preserved and reused as instructive materials. Architectural heritage is always open for interpretations and it is possible to analyze innovative aspects in each interdisciplinary study because of the fact that they always say something new to the experiencer.

Architectural heritage enables researcher to learn from them with a theoretical approach and use the gained knowledge to make interpretations by reading different elements shared in coexisted lost or damaged artefacts (Di Mascio, 2015).

In his studies Di Mascio claims that architectural built heritage might be analyzed from different perspectives and different features might be brought into the forefront in each study. Di Mascio highlights five characteristics to be analyzed as morphological, constructive, evolutionary, perceptual, functional characteristics each adding new layers of tangible or intangible aspects and improving the management, comprehension or valorization in studies on architectural heritage.

• Morphological:	The first contact with an artifact is visual. If we are not able to understand, represent and document its general morphology, we will never be able to break it down and analyze its single elements, or to understand the structures that regulate it.
• Constructive:	The concept of constructive peculiarities indicates the constructive system of an artifact, referring to the number and type of technical elements and the materials that compose it, to which requirements it corresponds and how they are connected/assembled.
• Evolutionary:	The analysis of these peculiarities focuses on the temporal variable which has been considered in two different ways, both combined by the progression of the actions. At first, it has been considered the transformations which have interested an artifact or a settlement during the centuries or years, and they have influenced the actual configuration; afterwards, the various realization phases of an artifact, characterized by the assembling or a progressive construction of technical elements have been considered.
• Perceptual:	The perceptive phenomena, which are intangible as lights, shadows and colors, characterize an artifact of a settlement as well as the tangible features, because the whole of these phenomena contributes in making a unique and unrepeatable built environment, characterizing its atmosphere.
• Functional:	The spatial arrangement inside the same room and between different spatial units, both horizontally and vertically. This aspect directly affects the movement in those spaces; the arrangement and sequence of spaces are key elements that contribute in the experience of a place.

Figure 2.15. Five characteristics of architectural heritage studies (DiMascio, 2015)

Storytelling in architecture, one main aim of this study, is stated as "narrative architecture" in Di Mascio's studies. He defines narrative architecture as;

> A narrative architecture is an architecture that, like a book, communicates a story through its tangible and intangible features. A story implies impressions,

> reflections, sensorial and cultural emotions presented during a path through one or more spaces. These characteristics are then communicated during the direct experience of a building. (Di Mascio, 2015, p. 202)

This firsthand experience is intended to obtain in this study but in a virtual form. Interactive storytelling presentations created in virtual environments might mirror the real environments or create artificial ones and allow all the physical information to be transferred into digital. With this transferred digital information, a story of tectonics can be written and told in a virtual environment with minimum loss of information and maximized user experience possible in a virtual platform. In order to avoid any misunderstanding, it should be stated that storytelling is used in this study with the help of traditional visualization techniques as static images and diagrams like exploded or expanded views together with explanatory texts. Together with increasing adoption of new presentation techniques allowing more interactive narrations, knowledge transfer between presented object and learner or explorer comes way closer to its full potential. These new presentation and representation techniques provides users with a more valuable user experience, and -with the enhancement of interactivity- a better ground for knowledge transfer about the presented object.

Figure 2.16. Image taken from “Virtual Tour of the Oriental Institute Museum”

Source: URL(17)

This study focuses on digital timeline-based storytelling authoring offering an editable virtual comprehensive interaction environment for construction techniques and structural tectonic analysis. That virtual environment promotes the feeling of presence of users with the help of computer displays in cases that might be impossible to experience by majority of the users in real environment (Papagiannakis et al., 2018). Validity of using animation and game technologies in presentation of tectonic construction process of digitally reconstructed architectural heritage in scale of a case structure is discussed throughout the study. Today there are many presentation examples of built or unbuilt architectural projects, but this study focuses on not just visualization of the cases but also creating an immersive experience platform of historical structures and their architectural heritage values. One of the main aims of this method is documenting the story of structures and environments consisting of construction, adaptation, historical development and unfortunately destruction periods over centuries and visualize or demonstrate these periods in a virtual platform.

After all storytelling might be stated as one of the main features of architectural animations that is used in this study to transfer data since it might be used to tell spatial stories while telling the lifecycle of a structure or environment. Moreover, to increase the effectivity of interactions, immersion techniques are used as creating a virtual gaming platform and placing the virtual reconstruction of the case environment in that platform to be experienced.

2.6. Use of Immersion in Architecture for Better Interactions and User Experiences

Experience is a very powerful way of acquiring knowledge. Digital technologies are able to reconstruct not only physical objects or environments, but also experiences and connections to be established to perceive and interpret architectural heritage unlike traditional cognition techniques (Wartenberg, et al., 1998). To create more powerful presentation experiences, architectural profession realized and started to adapt developing immersive information technologies in 1960s such as movement simulations, energy analysis or realistic imagery models as revolutionary tools in that time. MIT Media Laboratory first demonstrated Dataland multimedia system in 1970s, which was a collocation of today's ordinary multimedia tools like computer-generated sounds, imagery, video and texts. Continuing developments in information technologies brought many different methods of virtual environment creation and tools to experience them better (Maver, 2015).

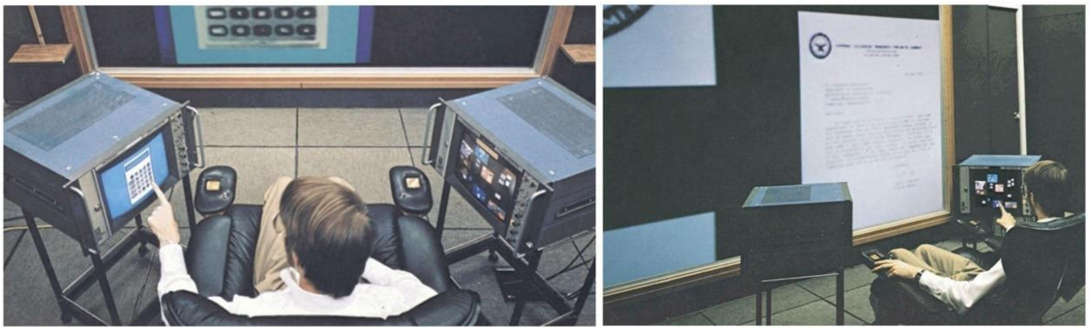

Figure 2.17. Dataland Multimedia System

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With these adaptations, architectural heritage has gained new tools for documentation and production in the last decades as 3D printers and laser scanning, on the other hand new immersive tools were adapted as CAVE, VR, AR and MR which will be discussed in next chapters. In this study, presenting access to architectural heritage in virtual environment is aimed as similar studies until today have brought positive impacts as popularization of heritage and more protection correspondingly with this popularization. On the other hand, new technologies are also used in marketing of architecture. Architects today are equipped with many media devices to use in professional activities to stimulate their clients and encourage them to get interacted with their design. Clients are able to perform multidimensional virtual tours into 3D or 4D models to replicate interactive activities to be performed in the future, and these comprehensive interactions goes way beyond traditional information transfer methods.

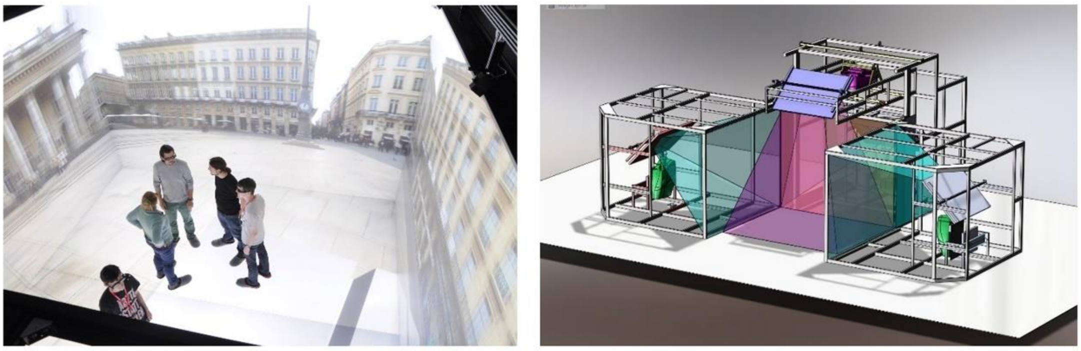

Figure 2.18. An example of CAVE virtual environment

Source: URL(19)

Figure 2.19. Immersive multimedia technologies in Van Gogh art exhibition

Source: URL(20)

Today, to gain detailed knowledge about an object, interactivity is the key factor defining the efficiency of cognitive process. As architectural models and visualizations are considered as predetermination of the way an object is going to be perceived, and this predetermination is fulfilled by the contact with that object in real life; virtual reality technologies create virtual environments or cyberspaces that enable user to experience that interaction during the earlier design phases and have better perceptions beforehand. In today's world of information technologies, interactivity mediated by new media tools adapted to architectural uses, introduces new sequences of events into architectural heritage and tectonic studies day by day (Zaplata, 2015).

To summarize, as intended in this study, immersive technologies might be used as experience development tools and a comprehensive knowledge sharing platform in architecture as in any other field of interest, with the developments that bring virtual and real environments closer to each other. This tool might be adopted in different cases in the interest of saving time and reduce the material wastage.

CHAPTER 3

EXPRESSING AND CLARIFYING TECTONICS IN THE PRESENTATION OF ARCHITECTURE

> "A great building, in my opinion, must begin with the unmeasurable, go through measurable means when it is being designed, and in the end must be unmeasurable." (Kahn, as cited in Wurman, 1986, p. 89)

3.1. Tectonics in Architecture

Design is usually defined as a set of decisions which determines the relationships between shape, material and performance. Even if there might be different variables correspondingly with different domains, the main activities of design are similar for each (Kan & Gero, 2017). Tectonic understanding is possibly needed more than ever in today's mass-produced architectural practice and discourse. It has an important role in creation of valuable and meaningful architectural environments. Maulden defines tectonics in architecture as:

> Tectonics is defined as "the science of art of construction, both in relation to use and artistic design." It refers not just to the "activity of making the materially requisite construction that answers certain needs, but rather to the activity that raises this construction to an art form." It is transcending the banality of mere building by the modeling of a physical thing which reveals a conscious attempt by the architect to "tell a story": bringing the physical into meta-physical world. Tectonic expression concerns itself with the narrative capacity of a building, primarily with respect to itself, but also as part of a more general circumstance (physical, social, political, economic etc.). In short,

> tectonics is primarily concerned with the apparent self-consciousness of a building with respect to its construction. (Maulden, 1986, p. 11)

Tectonics in Architecture might be defined as the fundamental knowledge of relations between each part that forming a structure both physical and metaphysical. Tectonic understanding includes both intellectual and material necessities of a structure as ingredients of a recipe forming something else as a total without losing their meanings, for example; context, design approaches and building technologies are analyzed together with concrete, glass and frameworks to discover relations between them. In a publication of The Royal Danish Academy of Fine Arts, Vitruvian triad of tectonic understanding; venustas, firmitas and utilitas, which will be discussed further in this study, is stated as:

> Tectonic design then holds a creative idea, which acts as a directing and structuring principle – an overall principle that materialize constructions into coherent structures… by this definition tectonic work discusses artistic design -venustas- based on architectural physical structures and materials -firmitas- rather than focusing on functional aspects of architecture and its everyday use -utilitas- (Bech-Danielsen et al., 2012).

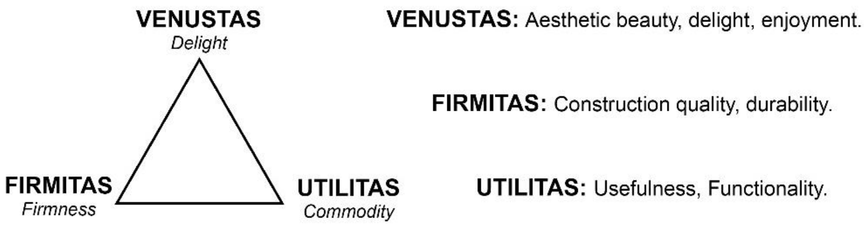

Figure 3.1. Vitruvian triad of tectonics in architecture

When historical development of tectonic understanding is studied, it can be seen that the term has its origin in ancient Greek. Kenneth Frampton states that the term “tectonic” is derived from Greek word “tekton” meaning carpenter or builder. Its reflection in Sanskrit is “taksan” meaning “craft of carpentry”, and similar terms can be found in different cultures as Vedic poetry. In Greek literature “tectonic” is used as “art of construction” and in Sappho’s works this term is used with a poetical meaning and carpenter of a structure is likened to a poet. The meaning gets broader in time from “carpentry” to a general term related with “making” and the artist becomes master builder “architekton”. In the recent past this ancient origin of the term evolves into a more artistic and philosophical word tectonic and is defined as “construction or making of an artistic product” (Frampton, 1995).

Tectonic knowledge had a key role while forming organized society in ancient civilizations, since it brought establishment of an order creating all kind of structures and artefacts including ships, walls, tools since it was perceived as knowledge to build in general, not only in architectural manners understood today (McEwen, 1993). The outcome of tectonic craftmanship might be stated as materialization of immaterial in general sense as Holst states that first architects relied on tectonic knowledge building monumental temples and defining a cultural landscape of a region (Holst, 2017).

Firmitas, durability element of Vitruvian triad is generally concerned about permanence of structural system including foundation and load bearing components and their service through long ages, and this necessity required use of durable materials and connections which can resist and endure not only dynamic but also static external and internal factors. But in this manner, Vitruvian understanding from classical periods of architecture is concentrated on primary elements of a building as structural system, but other physical elements are designed so that they might be changed (Vitruvius, 2015).

Differently from classical architectural understandings, modern western architecture and architects shaping this period such as Frampton, Semper and Bötticher create a modern tectonic understanding and state that enclosure elements and all other components of buildings are different parts of tectonics just as structural system

(Frampton, 1995). Karl Friedrich Schinkel reinterprets ancient tectonic understanding and states that constructive parts creating the dynamic whole express themselves individually conveying liveliness, freedom and rest (Schinkel, 1979). After that Bötticher formulates modern tectonics as building to answer both physical and spiritual needs, considering the whole as an artform that also lets materials to express themselves individually as dynamic parts of the static whole (Bötticher, 1874).

Frampton also analyzes Botticher's tectonic studies. Karl Botticher in "The Tectonic of the Hellenes" distinguishes Kernform (Core-Form) and the Kunstform (Art-Form) analyzing a Greek temple, and that becomes an advancement in defining tectonics in architecture. He states that timber rafters which is a part of core-form and serves structural wellness of temple and its representations are used as ornamentations on different parts of structure as triglyphs and metopes serving art-form of it. As a result, he defines tectonics in architecture as combining different parts of the structure to create a single and complete whole.

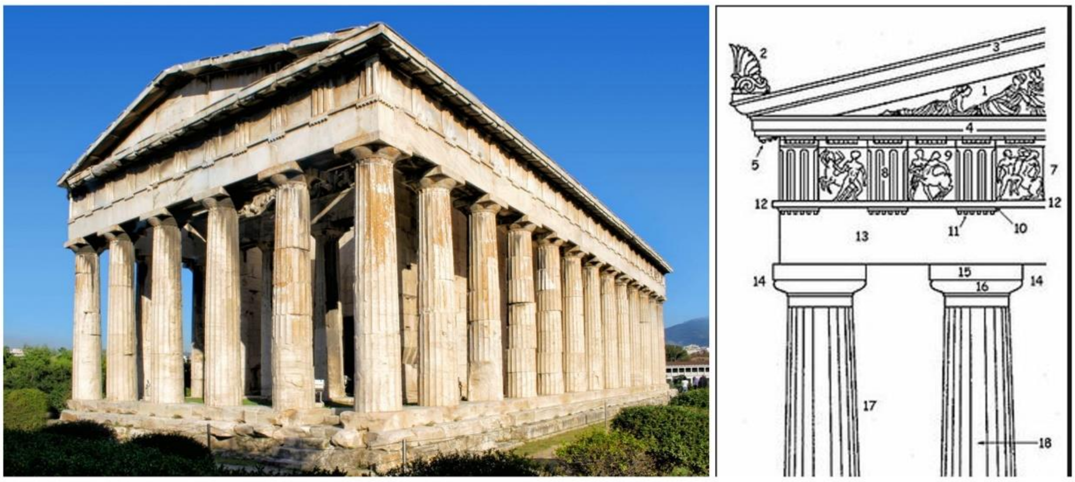

Figure 3.2. **Left:** Temple of Hephaestus, **Right:** Triglyph ornamentations

Source: URL(21), URL(22)

After his etymology studies, Kenneth Frampton defines tectonics as a conjunction point of phenomenological or fundamental basis of a building and its constructional and structural aspects.

> Without wishing to deny the volumetric character of architectural form, this study (Studies in Tectonic Culture) seeks to mediate and enrich the priority given to space by a reconsideration of the constructional and structural modes by which, of necessity, it has to be achieved. Needless to say, I am not alluding to the mere revelation of constructional technique but rather to its expressive potential. Inasmuch as the tectonic amounts to a poetics of construction it is art, but in this respect the artistic dimension is neither figurative nor abstract. It is my contention that the unavoidably earthbound nature of building is as tectonic and tactile in character as it is scenographic and visual, although none of these attributes deny its spatiality (Frampton, 1995, p. 2).

While Semper and Bötticher state that structures are composures of two different components as structural system and art, in this manner they accept art as a constructional component, in addition to that, Semper made a cultural interpretation of tectonics stating that tectonics defined different material use in architecture and explained that as a cultural phenomenon (Oxman, 2012). According to Frampton, structural systems form ontological characteristics of tectonics, on the other hand all other components such as skin, coverings and partitions are expressive characteristics of tectonics (Frampton, 1995). Tectonics is also an essential element in modern architecture as Frampton emphasizes tectonics as “poetics of construction” and states that structure and construction should be well integrated to contribute form and space.

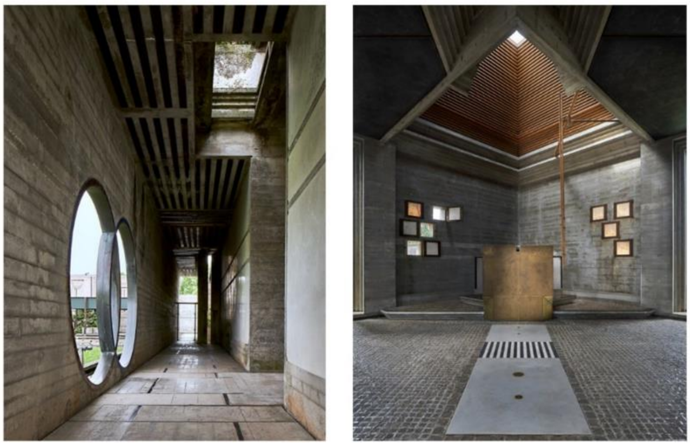

Figure 3.3. Brion Tomb by Carlo Scarpa

Source: URL(23)

More recently , Architect Özlem Erdoğdu Erkarslan makes a phenomenological study on Onur Teke's "T House" which has won a National Architecture Award in 2016 with reasons stated as "building's calm and unique contextual relation with its geographical location, association of materials and structure, harmony of inner and outer spaces, and successful cooperative relationships between detail and whole". In her study, Erdoğdu Erkarslan states that while structural system keeps building elements physically stable against gravity, grammar which can be defined as relations between pieces and whole -meronymy- forms architectural tectonics of building. Architectural tectonics is more related with what structural system means for the ones experiencing the building than how it was designed (Erdoğdu Erkarslan, 2017).

Figure 3.4. T-House by Onur Teke

Source: URL(24)

To make a summary, tectonic understanding in architecture might be explained as collaboration of each pieces in an architectural task including material and immaterial elements to form a better whole. In tectonic understanding, architect tends to create well-crafted buildings that stirring well-being for communities while holding a transcendent spiritual meaning beyond the physical artefact itself (Graf, 2011).

According to Moneo, architectural knowledge embodied in built environment might be gained evaluating the materialization of ideas inherent in different structures. He claims that the process of “making” is the way that architecture explains itself and is shaped by the mediation between imaginations, ideas and constructed work (Moneo, 2010).

Figure 3.5. TBMM Mosque interior, by Behruz Çinici

Source: URL(25)

3.2. Materialization Process

Architecture is in a revolutionary transforming process and there is an attempt for revitalizing involvement with material technologies and practice (Oxman & Oxman, 2010). With recent developments, computational processes and information technologies adapted in architecture, enables mediation between triumvirate of form, structure and material; that possibility of mediation through digital tools starting from conceptual stages to production arouses interest in tectonics in architecture correspondingly (Oxman, 2012). Tectonic understanding was redefined many times and level of interest in architectural tectonics changed throughout history. Rivka Oxman claims that tectonics in architecture fortunately became seminal in architectural discourses as a result of revival of interest in cultural heritage. She defines tectonics as a seminal concept of relationship between materialization of a structure and architectural design of it, which is formed and changed together with both evolution of this symbiotic relationship and contextual knowledge of place and culture in different time periods (Oxman, 2010).

It can be said that tectonic understanding in architecture is a tool to combine architectural fundamentals with structural aspects and materials in the correct way. This combination needs creativity and exploration in building up a whole structure which is possible by cooperation of several physical and metaphysical pieces. Even if architecture starts with ideas and their expressions on different medias, architecture needs to undergo a materialization process to be completed. As Peter Zumthor states;

> Architecture is always concrete matter. Architecture is not abstract, but concrete. A plan, a project drawn on paper is not architecture but merely a more or less inadequate representation of architecture, comparable to sheet music. Music needs to be performed. Architecture needs to be executed. Then its body can come into being. And this body is always sensuous. (Zumthor, 2006, p.66)

While creating a structure or an environment suitable for human living which is a core purpose for architecture, architects should be concerned about accuracy of construction and find the beauty in this construction beside delightful images created. It can be said that architects should have a structural awareness that serves as a helpful toolset to be more creative in future materialization processes and find alternative solutions suitable for their design. These alternative solutions can be created as a subconscious response when faced with a structural problem, but with the benefit of knowledge gained during previous works starting from education, some of these alternatives may be matured as a proper solution. Rivka Oxman claims that tectonic expression has its origin in vernacular building traditions and states;

> Vernacular architecture represents the essence of material technologies in providing a direct understanding and expression of the structural and constructional nature of the material. It defines the essence of the relationship between form and structural and material relationships in being a direct statement of constructional processes, where choice of local material results in the expression of form and structure. The choices of structural materials inform the construction process. (Oxman, 2012, p. 430)

Figure 3.6. **Left:** Traditional Tibetian House, **Right:** Jianamani Visitor Center

Source: URL(26), URL(27)

It can be said that, this kind of tectonic interrelations in vernacular constructions create an assembly of construction process and structural system both informing each other. In origins of vernacular architecture, material technologies have become building systems that express both material and construction process in time, moreover that direct exposure of material is emphasized as a direct expression of tectonics.

> Today, the prioritizing of materialization is a dominant theme of the cultural shift. As a design cultural phenomenon, contemporary tectonics is currently turning away from the interpretation of tectonics in the modern period. While modernism separated shape, structure and surface, tectonics in material-based design culture integration is emphasized. As a result, the integrating of form, structure, material and their fabrication/construction process return material and production considerations to the definition of the tectonic. (Oxman, 2012, p. 431)

Correspondingly with the use of information technologies, digital media mediated a new tectonic understanding in the last decades and William Mitchell introduced the term digital tectonics (Mitchell, 1998). He also described a virtual environment accommodating representation of materiality with the term ‘virtual materiality’ that ignores earth and structure relations which is an important factor in modern tectonic understanding. However, digital tectonics creates new perspectives of relations between information technologies and tectonics in architecture and reemphasizes the function of materiality in architecture. Later on, digital tectonics have been identified differently many times in various studies and became a formative factor in the search for new construction technologies.

It might be said that digital tectonics is based on a holistic structuring process and digital materiality reflects the material through its integration with surface which enhances the role of material in tectonic understanding. That process of digital design and materiality makes architect, engineer and constructor responsible for the total conceptualization and materialization all together (Oxman, 2011).

3.3. Presentation of the Materialization in Tectonic Analysis of Sample Buildings

Designer uses acquired knowledge during design process to generate and evaluate design ideas to achieve a goal within various constraints and present optimum creative solution (Lawson, 1997). When people aim to achieve a goal, the first thing they do is activating their knowledge relevant to the achievement within that context and creating relationships between knowledge and provided information about the given task while categorizing the elements of that achievement according to previous experiences (Chrysikou, 2008).

Case studies in architecture might correspond to main experience development method and play a very significant role in architecture education and profession as inspiring sources of information for architects. As Peter Zumthor states;

> We carry images of works of architecture by which we have been influenced around us. We can re-invoke these images in our mind's eye and re-examine them. But this does not yet make a new design, new architecture. Every design needs new images. Our 'old' images can only help us to find new ones. (Zumthor, 2006, p. 67)

Tectonic understanding in architecture promotes a homogenous association of design ideas which can be perceived as more intangible part of architecture and structural properties which is more tangible and physical part. Many inspiring structures of architectural heritage are produced with the awareness that physical structure is something that contributes architectural design, but not an obstacle.

> Twenty-five years ago, when I was a student, we were taught design through the analysis of architectural masterpieces. We would analyze a work by Corbusier, Wright, Mies, Hoffman, Loos, Lutyens, Ledoux, Palladio, Bernini, Borromini or others for volume, mass, structure, fenestration (windows and openings), landscape, vertical circulation or façade. All over the world, for some inexplicable reason, most likely the use of the computer by amateurs, universities began to teach design through the analysis of data. For the last two

decades students have been taught to analyze transportation, financial markets, library catalog systems, or other extra-architectural statistics and turn that into a form and then interpret that form as architecture. By architects of older generations, this is often skillfully interpreted through the transformed language of Corbusier, Mies or others, but for students who have never been taught design skills through the analysis of great works of architecture, the results are less meritorious and certainly less interesting. (Lynn, 2010, pp.7)

CHAPTER 4

CONCEPTUAL FRAMEWORK A 4D ANIMATION SUPPORTED CINEMATIC GAMING PLATFORM TO ENRICH ARCHITECTURAL PRESENTATIONS IN A VIRTUAL ENVIRONMENT

4.1. Reality Analysis and Virtual Environments

Since this study focuses on an application strategy in virtual environment as a presentation medium for an architectural structure present in the real environment, it is necessary to understand the interrelations of realities. This study aims to juxtapose real and virtual learning environments for better transfer of information.

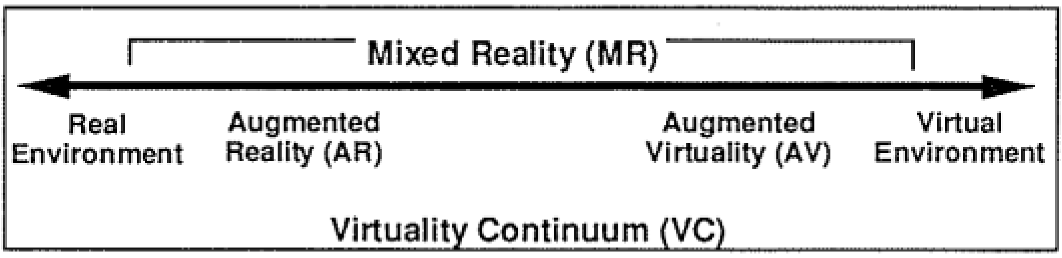

Figure 4.1. Virtuality Continuum (Milgram & Kishino, 1994)

In their studies Milgram and Kishino mention the connection of real environment and virtual environment and subcategories created by their relations in different levels as Augmented Reality (AR), Mixed Reality (MR) and Augmented Virtuality (AV).

Milgram and Kishino state that important point for this case is differentiating real and virtual. So, their distinction of “what is real?” and “what is virtual?” is based on three different aspects. First, distinction between real and virtual objects. While real objects allow direct observation, or sampling and resynthesizing on a display; virtual objects need simulation. Second, direct and non-direct viewing. While real objects allow direct or unmediated viewing, virtual objects need data sampling and resynthesizing or reconstruction of this data using some display media. Third, distinction between real and virtual images. While a real image is defined by having some luminosity at its location in the field of optics, virtual image can be defined as image without luminosity at its location. (Milgram & Kishino, 1994)

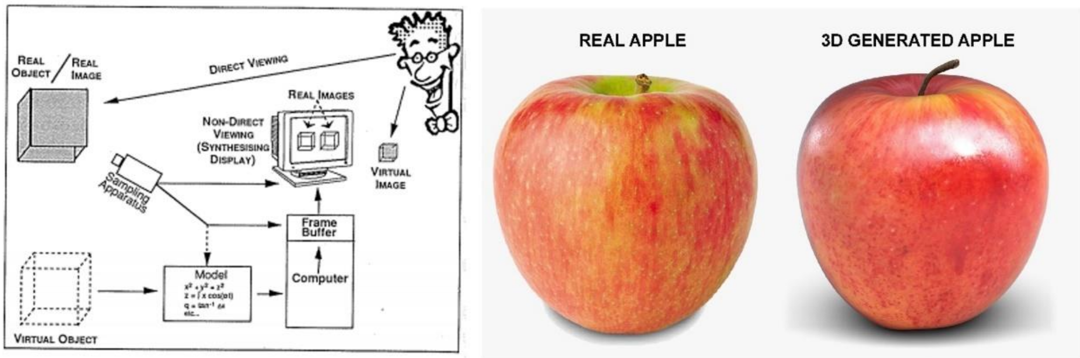

Figure 4.2. **Left:** Real and virtual object diagram (Milgram & Kishino, 1994), **Right:** Real and 3D generated apple

Source: URL(28)

After Milgram and Kishino’s definitions and studies on realities analysis, today virtual environments became way more acceptable and they are used in many different fields. It can be said that virtual environments give users opportunity to create and modify objects or situations using construction and programming tools. (Girvan & Savage, 2019)

Use of virtual environments are so common that many virtual worlds made of virtual environments are created and being used today. Girvan defines virtual environments and virtual worlds as simulated spaces that are shared and shaped by their inhabitants (Girvan, 2018). Users experience these spaces as navigating and construct a worldwide shared understanding through interactions with virtual object and other users from the real world (Girvan, 2018).

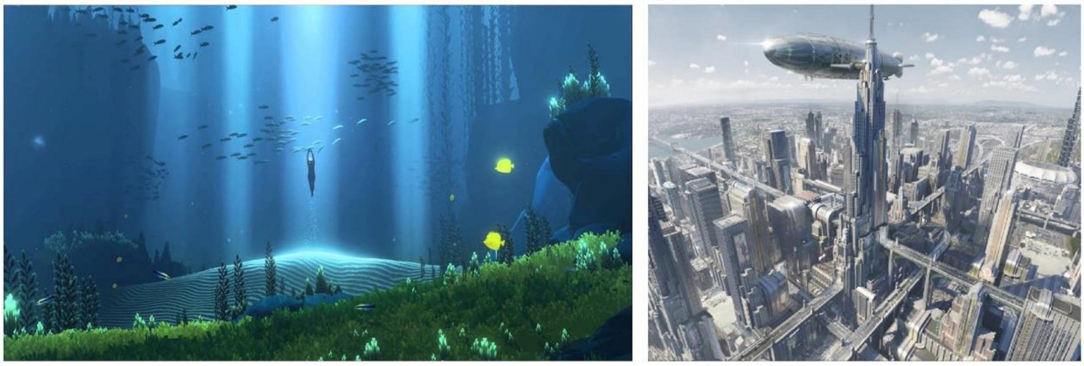

Figure 4.3. **Left:** In game visuals of deep diving from the game ABZU, **Right:** Art deco virtual city by Mitchell Stuart

Source: URL(29), URL(30)

One of the most important difference between virtual environments and real environments might be that, virtual environments allows users to experience many different combinations of situations created with technical possibilities providing users with a collaborative learning environment that might not be possible to afford for many learners in real environments. With the enhancements in virtual environments; virtual lectures and field trips, socialization and simulations became easily accessible for any academic fields (Ghanbarzadeh & Ghapanchi, 2018). Although virtual tools and environments might offer the same learning experiences to each user, as in any other teaching or learning method, how the learner experiences the offered possibilities might vary on an individual basis. This differentiation might depend on individual user's experiences with virtual environments such as games, real environment that virtual environment is accessed from, and other social experiences that might enhance sense of presence.

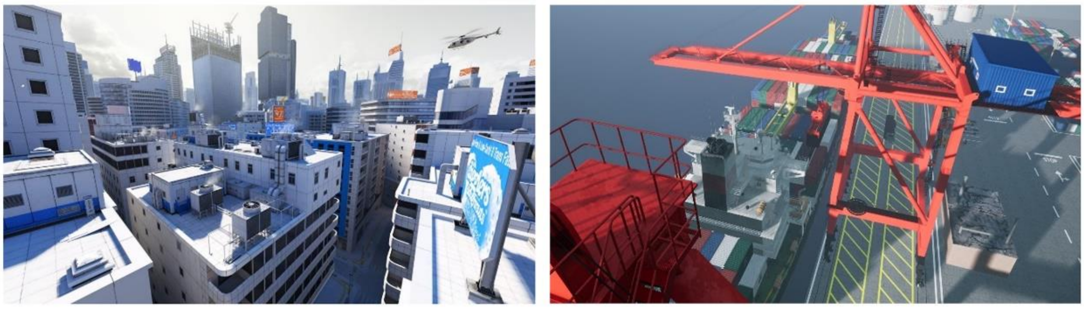

Figure 4.4. **Left:** Virtual city image taken from the game Mirrors Edge, **Right:** Virtual dock designed with Unreal Engine

Source: URL(31), URL(32)

As Iryna Kuksa and Mark Childs states, virtual reality is generally defined as

> A computer simulation of a real or imaginary system that enables users to perform operations in virtual spaces and shows effects in real time. It is also a part of the global information and communication infrastructure or cyberspace (Kuksa & Childs, 2014, p. 3).

Since the term ‘real’ is generally perceived as things that are explored through senses and with current technology senses can be manipulated, terms ‘real’ and ‘unreal’ might be confused and interchanged. This integration and naturalization of reality convergence and change in reality perception starts with reality manipulation in media transformation such as invention of photography and television. On the other hand, as all artificial and virtual environments might have correlations with real environments, they might be completely imaginary as well. (Bolter & Grusin, 1999)

With latest advancements in VR technologies, virtual environments now have the power to manipulate sensory system of user by creating responsive images and sounds in reaction to actions of user. This feature of VR, on the contrary to traditional media tools as cinema, makes this technology to create a very powerful feeling of physical and mental involvement in virtual environments. With all the advancements VR technologies is not the only factor to set the limits of user’s engagement with the virtual environment. In virtual environments, this being completely involved might be stated with the word ‘immersion’. One of the main aims of virtual environments is making users be immersed using interactions and reality manipulation, but this immersion also depends on some other factors than technology itself. For example, as Murray and Sixsmith states, sensory inputs that user is exposed from the real environment while experiencing a virtual environment or perception of body while experiencing a discrepancy between virtual and real movements might disrupt this immersion. (Murray & Sixsmith, 1999)

With all advancements in computer graphics, real and virtual environments have come so close to each other, almost indistinguishable in some cases. Latest computer game environments would be good examples of real environments reflected in virtual environments. For example, in a leading game company Rockstar’s flagship game Grand Theft Auto, all the environment of game is set in Los Santos, which is a fictional city based on Los Angeles.

Figure 4.5. Santa Monica Ferris Wheel v Del Perro Ferris wheel in GTA V

Source: URL(33)

Figure 4.6. Famous Chinese Theatre, LA v Vinewood, Los Santos in GTA V

Source: URL(33)

In this study, it is aimed to catalyze the learning of AEC related people with the help of a virtual environment created using Unity game engine and computer screen is the chosen media to display the end products of this study.

4.2. Immersive Technologies VR – AR – MR

New ways of spatial environment representation brought new technologies that better connects virtual and physical worlds to conceptualize space. Spatial environment representations today such as virtual realities, mixed realities or augmented realities are able to manipulate the sense of reality by converging real and virtual ones. These relatively new technologies juxtapose visual and mental narratives and make experiencer to interactively create contents and make interpretations. With the use of these technologies, it is possible to combine conceptual tectonic relationships created in virtual environment with spaces in real environment to reach a more commonly accepted way of learning and facilitate progressive knowledge building. This interconnection of real and virtual environments is achieved by overlaying data from both and representing them correspondingly with user decisions. Today, it is applied in diverse range of disciplines as tourism, education and preservation by advancing the idea of learning without time or place boundaries. (Zarzycki, 2015)

VR - Virtual reality is defined as the use of computer graphics together with various display devices to provide immersion effect in a computer-generated interactive 3D environment (Pan, Cheok, Yang, Zhu, & Shi, 2006). Virtual Reality requires an absolute isolation from surrounding real environment visually and allows user to experience a purely artificial environment of rendered images that replaces the real one. Two most important objectives of VR are creating immersion and interaction for the user (Fuchs, Moreau, & Guitton, 2011).

AR – Augmented reality might be defined as a system that overlays digital information and content on real world environment to co-exist (Azuma, 1997). AR creates an immersive experience which superimposes virtual objects upon user’s view of surrounding real environment with required media tools, and that generates an illusion of these objects' presence in real world (Azuma, 2017).

MR – A relatively new immersive reality technology is mixed reality. Mixed reality is a hybrid of virtual and augmented realities that merges real and virtual environments. In mixed reality, physical and digital objects are combined in the same layer. Imagery synthetic objects and virtual environment are able to interact with the user, objects and the surrounding real environment in MR.

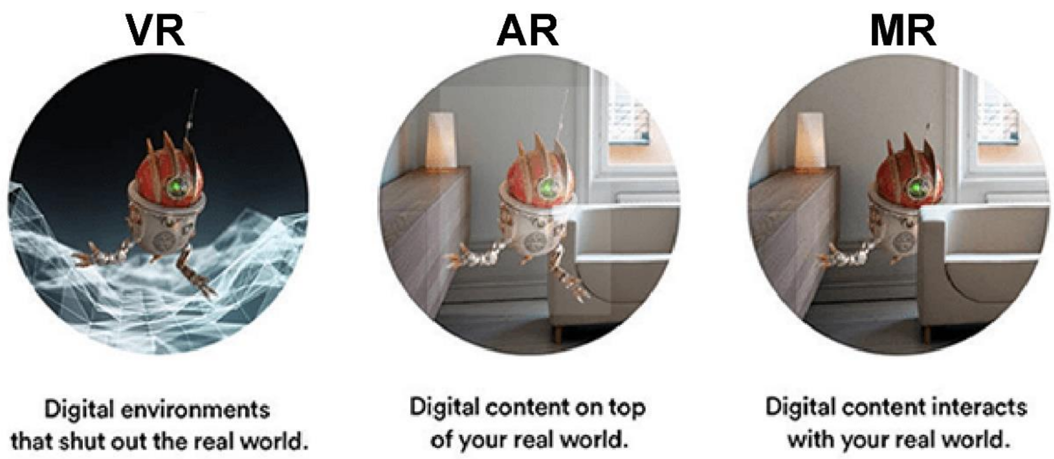

Figure 4.7. VR, AR, MR comparison

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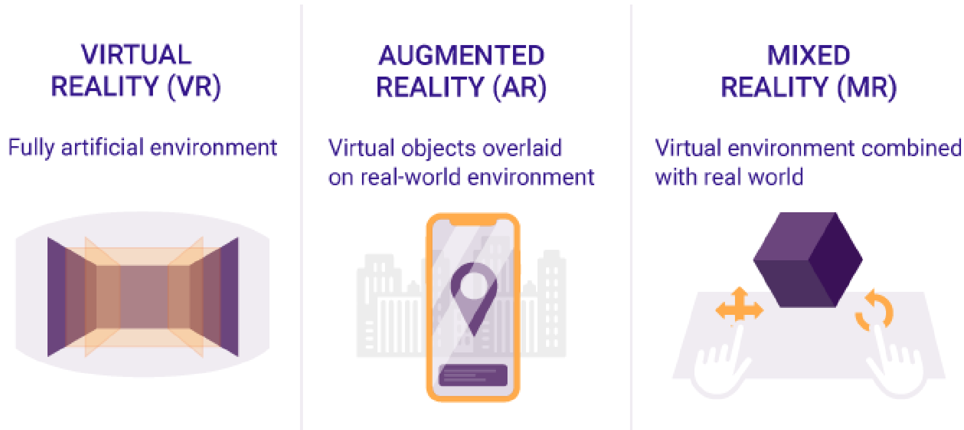

Figure 4.8. VR, AR, MR comparison

Source: URL(35)

4.3. Computer Screens to Display Virtual Environments

New tools of digital era became essential for research and preservation of architectural heritage since modern culture is overwhelmingly expressed by images created with different digital tools With all the developments in technology supported all along the study, one may question 'why this study chooses computer screens to display virtual environments, but not virtual reality glasses or mixed reality lenses?' Primary answer to this question would be that computer screens are still way more accessible than other display medias and it is kind of necessary choice to reach more people with computer screens until other media types are getting more affordable. In the search of new methods to represent architectural heritage including structures, objects and environments, to make it widespread and more accessible, participation through everyday digital tools as computers or mobile devices should be focused in this kind of a study. Secondly, end products of this study might be transferred to other medias with additional adjustments.

Figure 4.9. Computer screens are the most commonly used devices to display virtual environments

Source: URL(36)

4.4. Use of Games, Game Technologies and Game Mechanics in Architecture

4.4.1. Definition of Game

Interaction is taken to a whole new level by games, that is often underappreciated by people that don't play on a regular basis. One important feature of games that makes them good for experience development and knowledge gathering is the requirement for the players to prove that they understand the concept and rules of the game. Moreover, games include nested information by giving user different objectives and make the user to involve with the scenario and find ways to achieve the objective (Routledge, 2016).

Even if it is not necessary to deeply analyze the ludology, historical development or theory of games, to be able to talk about the use of game related developments in architecture it is important to make a definition of game in the first place and make a brief about recent relevant studies on games. Marlow states that games are catalyzers of learning environments and people begin learning from games in a very early age and this knowledge is generally permanent. Despite the fact that majority of games are considered, designed and played as a leisure activity, games provides people with an environment for practicing a variety of occasions and find solutions for problems which might possibly be experienced in daily life (Marlow, 2009). Beyond any doubt, games have always been a part of everyday life of humans starting from very early ages, but when modern studies on games are traced, the earliest academic publication reached related with games can be stated as Johan Huizinga's book Homo Ludens that was published in 1938 (Boes, 2014).

Figure 4.10. Children playing outdoor leisure games,

Source: URL(37)

According to Huizinga, game is an activity that players does not feel obliged but take part voluntarily just because they want to. Another characteristic of a game is that, rules and foundations of games don't have to be bounded to strict boundaries of ordinary life of the player, each game allows players to create their own reality that players are aware of, but this does not mean that games and their virtual realities are away from seriousness. On the other hand, no matter how serious and realistic the virtual reality of the game is, players are still aware of that they are pretending. Third characteristic of games according to Huizinga is that games are time and place independent. Time independence provides games with opportunity to be able to be repeated, transmitted to new generations and create traditions or culture. Besides time independence, place independence allows players to create an idealized virtual environment suitable for the game either physical or imaginary, and this environment of game gives opportunity to put everyday rules away and create new set of rules which enhances interaction between game and the participant. When someone spoils the game and breaks the illusion, while game keeps existing in another realm, participants comes back to everyday life. (Huizinga, 1949)

Figure 4.11. Hero Kids fantasy RPG game visual

Source: URL(38)

Marlow summarizes these characteristics stating games being sticky, enabling people to play them many times; being persuasive, leaving players no choice but interact and argue with game and other players by accepting imaginary features of possessed character; embodying systems of other disciplines or environments to create a larger pattern of its own and become a closed system with its own set of rules which does not have to interact with real world. (Marlow, 2009)

On the contrary to the assumption that gamers are solitary young males, the average gamer is between 30-40 years old social people and recently in some game categories like mobile casual games there is a balance between male and female users, in addition to that in the United States, 211.5 million people play games that makes almost two-thirds of population (Routledge, 2016).

Nowadays concept and general understanding of games have gone way beyond its limits and taken place in academic studies from many different fields such as health, business and archeology. Huizinga's Homo Ludens have always been accepted as a source of reference both for academics and people related with game design (Marlow, 2009). Today, games and game concepts are also used in almost all fields of activity other than entertainment industry in forms of gamification and serious games.

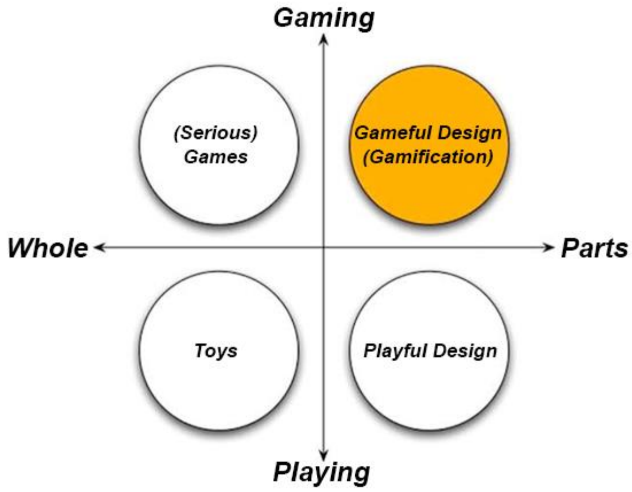

Figure 4.12. Serious games, gamification, playful design and toys diagram (Deterding et al., 2011)

On his analysis on this implementation of game mechanics in other fields of activity than entertainment, Csikszentmihalyi states that accomplishing a task without getting bored or frustrated brings happiness and explains this situation with the Flow Theory he created which specifies the optimal experience as flow state presents the state of getting involved in an activity voluntarily with full immersion and enjoying it (Csikszentmihalyi, 2008).

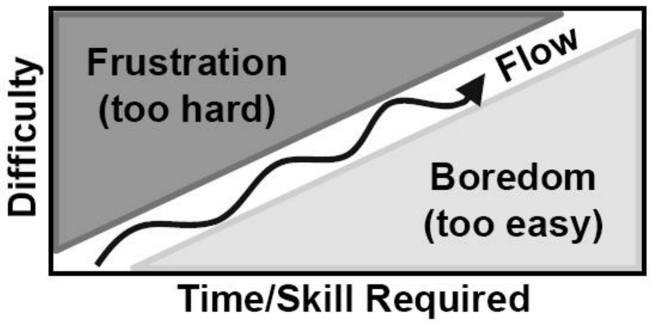

Figure 4.13. Flow Theory (Csikszentmihalyi, 2008)

According to Csikszentmihalyi, game mechanics are essential to get into flow state and he also identifies characteristics of flow that directly affects the motivation and engagement in designing gamified applications as created in this study, which are:

• A challenging activity which requires time and skills;

• Action and awareness integration;

• Concentration on the achievements;

• Clear goals and feedback (Csikszentmihalyi, 2008).

4.4.2. Gamification – History and Definition

> The application of typical elements of game playing (e.g. point scoring, competition with others, rules of play) to other areas of activity, typically as an online marketing technique to encourage engagement with a product or service. (“Gamification”, n.d.)
>
> or
>
> The practice of making activities more like games in order to make them more interesting or enjoyable. (“Gamification”, n.d.)

Gamification is an interdisciplinary approach that aims motivating users to achieve predetermined behavioral or psychological outcomes on specific platforms (Matallaoui, Hanner & Zarnekow, 2017). McGonigal claims that the term ‘gamification’ is originated in digital media sector and first documented uses were dated in 2008 and this digital concept was adopted by a great majority of industries in 2010 with the popularization in widespread conferences. (McGonigal, 2011)

There are two major ideas defining the term gamification with respect to the everyday experiences and game mechanics. The first idea supports game elements and games have always been influencing our everyday lives in different aspects. Creation of the term gamification was institutionalization and adoption of this present state. The second idea on the other hand, supports that games are designed with main aim of entertainment and this feature of games allow them to create desirable experiences that make users voluntarily engage in activities. So that, game mechanics might be important tools in making of enjoyable non-game contents having joyful characteristics of games for different fields of interest.

In the conference paper “Gamification: Toward a Definition” authors define gamification as “The use of game design elements in non-game context” and explain 4 main components of this definition which are;

Game: In the case of defining gamification, it must be clear that even if games are broadly connected with playful behaviors and mindsets, game and play are different terms. Games created in gamified applications are shaped around terms like rules, competition, goals and outcomes with less concern about playfulness.

Element: At this point authors claim that it is not easy to talk about a well-defined boundary between gamified applications and games, it is more related with the ascribed meaning by the maker. In the case of the term “elements” while differentiating games and gamification, it would be reasonable to say that, gamification is the use of characteristic game elements.

Non-Game Context: Vast majority of games are products of the entertainment industry and context of games are generally related with entertainment of the user. Even if it is not recommended to limit the term gamification, general usage contexts can be named as joy of use, engagement and user experience.

Design: Games and gamified applications can be built with the same design elements, both concrete and abstract ones. Authors categorizes these design elements into 5 levels as: Interface design patterns, as a rewarding system for the user; game design patterns; design principles as guidelines for problems and solutions; conceptual models of game design units; lastly game design methods as value conscious game design and play centric design. (Deterding et al., 2011)

Figure 4.14. Four main components of gamification (Deterding et al., 2011)

Gamification is a commonly used method in learning phases in many different fields. Since gamification method creates interaction between the product and the producer during production period, this interaction results in playful experiences for the producer. Cronk claims that;

> To encourage the use of games in learning beyond simulations and puzzles, it is essential to develop a better understanding of the tasks, activities, skills and operations that different game types can offer and examine how these might correspond to the desired learning outcomes. (Cronk, 2012)

In an article of IEREK (International Experts for Research Enrichment and Knowledge Exchange), relation between gamification and architecture is stated as;

> Gamification can be described as the use of gaming concepts into non-gaming contexts. It requires collaboration and engagement in any activity, bringing innovation to architecture world. Gamification introduces future for buildings regarding controlling the building itself as playing. Future hopes lie in filling the gap between Architect modeling and game development. Scholars are trying to create online scenario-based games to enhance learning and teaching architecture.
>
> Future holds a lot of creative and innovative ideas for our new world as it transforms contemporary architectural designs to different innovative concepts where the architect will develop his innovative skills and know-how skills to think more like a game designer but in a real and tangible world that will serve

customers and help in designing unique urban buildings.(Gamification of Architecture, 2016)

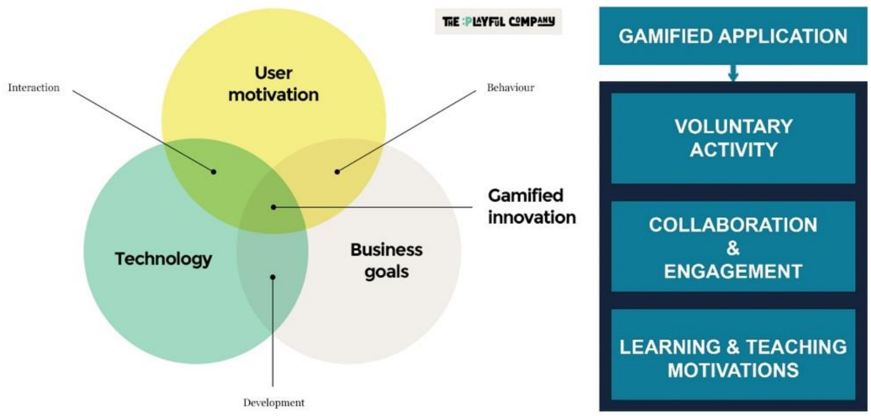

Figure 4.15. **Left:** Gamified innovation Venn diagram, **Right:** Gamified applications triggers voluntary activity, strengthen engagement and motivates learning and teaching (Gamification of Architecture, 2016)

Source: URL(39)

Even if most examples of current gamification are digital, gamification is not limited to digital technologies. As in any other field there is an increasing interest in digital media use when it comes to gamification, it should not be forgotten that game related issues are generally trans medial both digital and non-digital. (Juul, 2005)

With the latest developments in technology and researches made on the use of gamification in different professions, gamified innovation is found as an intersection point of user motivation, technology and business/profession goals. Today, game mechanics and gamification are applied in numerous studies to ensure better user engagement and drive voluntarily participation (McGonigal, 2011). These motivational features create a fertile environment for skill acquisition and encourages further development to occur in such vibrant environments (Spitzberg, 2006).

An important aspect of gamification, to make the task more entertaining and easily interactable for voluntarily player participation, is that complex tasks should be divided into smaller tasks using game elements correspondingly with the expertise level of the user (Seaborn & Fels, 2015). In their studies on brain mapping, Tinati et al. revealed that a great majority of their survey group referred gamification positively and willingly spent time on their virtual platform Eyewire, and deduced that applying game mechanics and gamification creates a motivational framework consisting of four categories as: the desire to contribute, to learn, to be part of a community, and to be challenged, entertained, and play (Tinati, Luczak-Roesch, Simperl, & Hall, 2017).

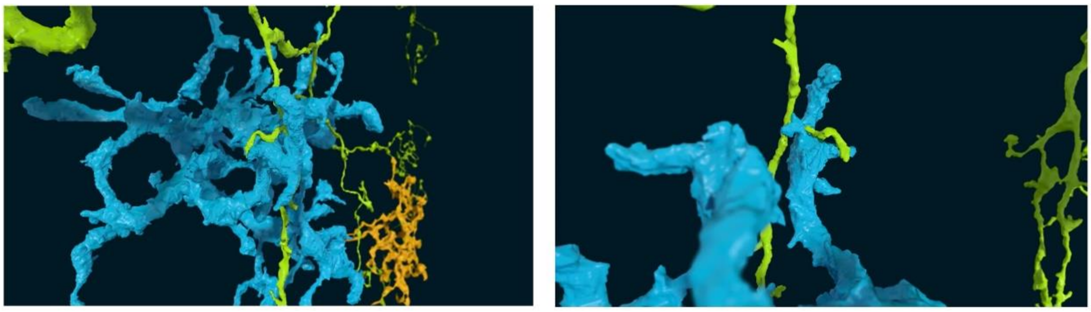

Figure 4.16. Brain mapping by a gamified application Eyewire

Source: URL(40)

4.4.3. Serious Games – History and Definition

> Electronic games whose main purpose is "serious" and not to simply entertain. The primary "serious" purposes can be to teach or train in areas such as education, health care, advertising, politics, etc. ("Serious Games", n.d., para. 1)
>
> or
>
> Digital games, simulations, virtual environments and mixed reality/media that provide opportunities to educate or train through responsive narrative/story, gameplay or encounters. ("Serious Games", n.d., para. 2)

Video games have many different subcategories. Even if when the term 'video game' is mentioned, majority of people pictures first person shooter or platformer games which are for mere entertainment in their minds, there are many games created based on storytelling authoring or purposes to provide players with experiences mirroring real environments of real world. Games catalyze learning in many different ways as Marlow States. Since games are interactive, they let player to affect the outcome to some extent and get affected by the virtual environment and virtual characters. Games provide player with opportunity to see the situation from different perspectives and explore new places or new situations with variables and see different outcomes by changing these variables, each giving a new experience which might not be possible in real environments. (Marlow, 2009)

According to Shaffer, since games have another very important feature as giving player chances to 'fail in safe ways' these failures enhances player with new outcomes and teaches new ways of knowing, doing, being and caring. Thanks to this important feature of games, players might develop powerful identities and understanding by failing and trying again. In addition, players of appropriate games develop a good understanding of social ethics and be able to share different social values from different cultures. (Shaffer, 2005) In the light of this information, researchers introduced a new term as 'serious games' which are engaging, reusable, cost-effective, in addition they offer a safe environment, complement other forms of experience development and transfer data to a wider audience (Routledge, 2016).

The term 'serious games' was first introduced by Clark C. Abt in his book 'Serious Games' in 1970. Abt defines serious game as;

> Games may be played seriously or casually. We are concerned with serious games in the sense that these games have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement. This does not mean that serious games are not, or should not be, entertaining. (Abt, 1970, p. 9)

Gonzalo Frasca is making another definition of serious games referring Abt's definition. According to Frasca, serious games are "Games that aim at training, educating, persuading or communicating values and ideas". (Frasca, 2007, p. 26) At this point a friendly reminder might be useful as while calling this kind of games ‘serious’ other types of games are not classified as non-serious. Although the term “serious games” is not common for majority of people and many started to hear about related developments recently, according to a market study done worldwide in 2010, market value of Serious Games is 1.5 billion € (Alvarez et al., 2019) And this market value is estimated to increase and reach 5.5 billion $ in 2020.

Figure 4.17. **Left:** ARA Virtual Heroes, a serious game for military training, **Right:** CareME, a serious game for healthcare education

Source: URL(41), URL(42)

With this increasing interest in serious games, they started to take attention from many diverse fields such as healthcare, military and education. Many entertainment companies working on video games started to play a part in this relatively new field on interest. For example, according to ludologist Gonzalo Frasca, a city building simulation game named SimCity which was released in 1989 might be considered as an example of serious games even if it was released with commercial concerns. Frasca states that since SimCity is allowing player to make decisions on interconnections of nature, structures, infrastructures and take actions according to short- and long-term consequences of these interconnections and create a functioning city or an urban environment. Although SimCity’s primary objective is mass entertainment, the end product serves some of the main purposes of architecture and urban design education. (Frasca, 2007)

A more recent example of learning from games might be Assassin’s Creed, a game saga made by Ubisoft. Assassin’s Creed games give opportunity to players to observe different cities worldwide at different timelines such as Florence, Paris, Jerusalem and

Damascus all from different centuries that is redesigned for game by a team of specialists from different disciplines such as architects, historians and urban designers. Assassin's Creed saga set a high-level detail quality on its architectural structures and urban environments.

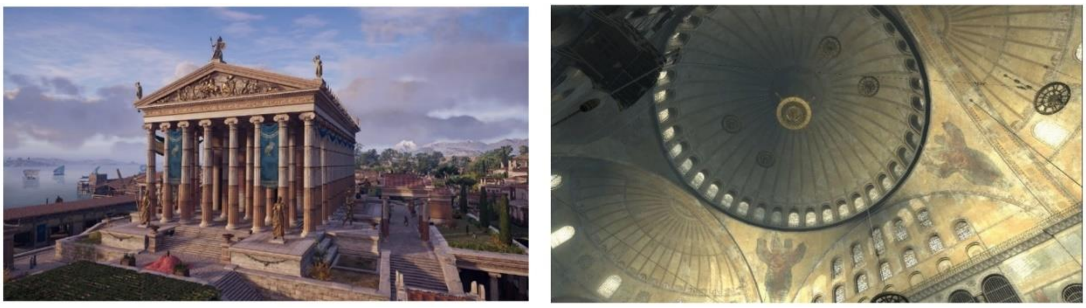

Figure 4.18. **Left:** Temple of Asklepios representation from the game Assassin's Creed Odyssey, **Right:** Hagia Sophia representation from the game Assassin's Creed Revelations

Source: URL(43), URL(44)

Although these reconstructions might not be taken as proper scientific reconstructions, they are captivating with their ability to enable users to experience something extraordinary, in the simplest form impossible, as walking in the cities and cultures existed centuries before (Pankiewicz & Hirschberg, 2015). After 2019 Notre Dame Fire, Ubisoft Company pledged aid for restoration of the cathedral. Company spokesman told the BBC News that they would be happy to share the digital version of the building with French authorities. That representation was modelled over a 14 months period and it was used in the game Assassin's Creed Unity which was published in 2014 (BBC News, 2019).

Figure 4.19. Notre Dame in Assassin's Creed Unity

Source: URL(45)

A closer example might be works of Reo-Tek, an interdisciplinary firm based in METU Technopolis that has an experience of at least 15 years on interactive technologies. With their own words, Reo-Tek defines themselves as;

> A full-service design and production company and developer of interactive technologies. From developing virtual reality software to producing interactive installations in museums, we do it all. We create interactive applications and installations for many industries ranging from education and cultural heritage to museums and exhibitions.
>
> Our interdisciplinary structure with industrial designers, interior designers, architects, computer & electronic engineers and graphic artists bring diverse expertise and unlimited creativity to the projects. ("WE ARE", 2018)

Kronosfer is a really good example of interactive learning software. It is an educational application of Reo-Tek that aims changing traditional education methods and create an interactive learning environment. Users can learn historical events not only on a chronological order, but also as connected elements of a global networks with cause and effect relation. Application allows users to control the timeline that includes events to be shown on the screen from the beginning of history to present day both in 2D and 3D. While user arrange the limits of timeline from both sides, events that happened between these limits pop up on the world map. When any event on the screen is clicked down, information and visuals about that event is shown on another pop-up window, moreover other related events are highlighted to make it easier for the user to perceive historical connections between different events.

Figure 4.20. Kronosfer Application created by Reo-Tek

Source: URL(46)

Optik Eğitim Sistemi, Optical Education System, is another example of Reo-Tek's interactive applications that can be called a serious game. This educational iPad application was supported by TÜBİTAK, Scientific and Technological Research Council of Turkey, and aims to teach optics science by experiences on experimental methods of optics. This application consists of two different parts as education and laboratory. Educational part uses storytelling texts and visuals to create achievements for the user, users gain knowledge on basics of optics science while trying to complete these achievements. On the other hand, laboratory part consists of a virtual table and optical tools to be experienced. Users locate different lenses, mirrors, lights and lasers as they wish and while playing with these tools, they learn refraction, reflection, concave and convex lenses and many other information about optics and all theoretical knowledge gained in educational part become permanent and concrete.

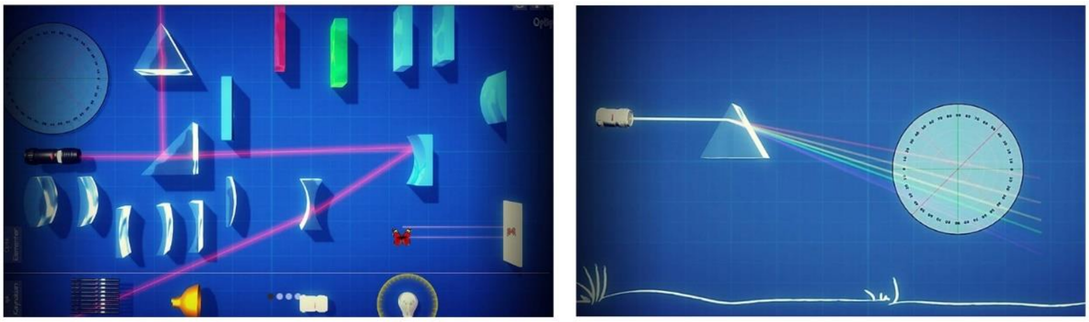

Figure 4.21. Optical Education System Application created by Reo-Tek

Source: URL(47)

Afterall it can be understood that serious games might be very helpful devices for design students. These games offer more interactive discoveries instead of passive learning techniques, and this characteristic lets players to feel consequences and reshape future actions correspondingly with these consequences. So, exploring different problems and their solutions both about virtual actors and environments help designers to develop an understanding on different issues and have user experience on design problems even before facing them. This beforehand experience teaches designers to have a comprehensive knowledge of details of a subject and encourages them to think and maybe act differently. In addition to that, when connected with online networks, serious games offer opportunities to create a domain for designers from different social and cultural environments where players can share their knowledge and learn mutually from online interactive applications. (Marlow, 2009)

4.4.4. Game Engines in Architecture

With the increasing interest in serious games of a variety of people from many different fields, game engine comparison and analysis have become an open discussion recently. Because of increasing demand for serious games and the fact that game engines are very helpful tools for the use of people with limited knowledge in coding to develop serious games, people without a background on game technologies also became interested in game engines for different needs of a variety of user profiles. (Christopoulou & Xinogalos, 2017) Implementation of game engines in visualization process of architectural heritage is also getting more common day by day, but potential functions of this technology are not commonly known and need deep investigations by researchers and clear explanations for possible users. The reason for that limited use of game engine features might be because of complexity of them for new users (Boeykens, 2011). Since programming skills and a steep learning curve is required for an effective use of game engines, this intimidates or discourages architecture related people that are rarely familiar with this technology. Despite these relatively challenging factors, game engines might be programmed using codes in different coding languages to offer experiences differently from other specialized visualization tools commonly used in architecture. As a solution, in a study like this, many obstacles might be overcome with interdisciplinary teams of experts having different backgrounds like architects, programmers, IT specialists, architecture historians, game artists and others in accordance with the needs of the project.

Game engines can be technically defined as platforms that game related tasks are done such as rendering, animating, input, physical computation and collision detection by developers. Game engines might contain reusable components to manipulate and create different games, thanks to that reusability, created games can be compatible for different platforms as computers and game consoles with some source code changes. For data processing of physics, sounds and video animation; game engines use specialized middleware that might be embedded or a third-party extension. For example, with Havok middleware as a physics engine and Unity game engine collaboration, Unity offers very realistic environmental effects in game plays. (Paul, Goon & Bhattacharya, 2012)

Figure 4.22. Unreal Engine used for visualization by Zaha Hadid Architects

Source: URL(48)

A more general definition for game engines can be that game engines are coded editorial software primarily used for video game development, but because of their powerful visualization and virtual environment creation performances, they are used in many different fields beside game development like architecture, filmmaking and advertisement. Many educational simulations and serious games are created from different fields to experience real environment challenges in virtual environments. In architecture, mainly because of their virtual environment creating tools and physics motor, game engines are used for 3D visualization and real-time rendering for architectural presentations in present day (Örnek, 2013).

Figure 4.23. Image taken from Unity showcase for AEC industries

Source: URL(49)

Many different game engines were developed in the last decade that are popular in different fields of interest including architecture beside entertainment industry. Three examples for well-known and most used game engines can be counted as Unity, Unreal Engine and CryEngine. Unity is a cross platform game engine developed by Unity Technologies in June 2005 as Apple Inc.'s exclusive game engine that uses Java and C# as coding language. With many major updates, it now supports many other platforms other than IOS (Apple's operation system). Unity is mainly used for creating simulations, animations and games for mobile devices, video game consoles and computers. Unreal Engine is developed by Epic Games and firstly used in an FPS (first person shooter) game Unreal in 1998. Unreal Engine uses C++ as coding language and features very good portability with its embedded developing tools. Even if it was created for developments of FPS games, now it is also used in many other fields as Unity does. As last example, CryEngine is another game engine example using C++ developed by Crytek and was used in a famous game brand Far Cry. As in any other game engine CryEngine was used in many other games by many other companies and modified many times until today. In April 2015 CryEngine was licensed to Amazon and a reworked version named Amazon Lumberyard was released in February 2016. Each software is updated at least once a year.

Since there are various game engines with different features and any game engine is not the best for every purpose, user or developer should decide to which game engine would be the most suitable tool for their needs according to their personal skills.

4.4.5. Game Mechanics via Unity

Making a comparison between different game engines is not easy, because there are many different features to be considered as multimedia and middleware support, rendering technique, coding language and platform dependencies (Paul, Goon & Bhattacharya, 2012). As in Windows-Mac or iOS-Android clashes, that is mentioned as wars between digital platforms, game engines also try to have the control over content creation fields as games or virtual platforms (Gillespie, 2010). Today, there is a similar raging and discrete rivalry between the game engines of Epic Games and Unity Technologies over the control of game industry (Takahashi, 2015). Besides game industry, these two companies are also competing for the dominance in virtual reality and immersive media for being the ultimate tool in interactive content creation (Foxman, 2019).

Among similar software like Unreal Engine and CryEngine, since it is more appropriate for a first-time experience with game engines, a powerful game engine Unity is preferred in this study to document and develop the virtual presentation platform. Other than being used with a modern and relatively easy to learn coding language C# extending its functionality, Unity has many other advantages. Thanks to the developed 'build and run' protocol Unity game engine is very powerful in the aspect of interoperability that allows publishing on different platforms, and this protocol is continuously updated correspondingly with emerging technologies (Foxman, 2019). Today Unity supports many different platforms including computers, mobile devices, game consoles and virtual reality devices all having different operation systems. Unity is used to create 2D or 3D games, simulations or other experiences and these end products can be designed to work with VR or AR devices also. Unity also has its own marketplace named 'Asset Store' that permits both professionals and amateurs to upload their scenes, codes, add-ons or complete packages to be used by other developers paid or free to create different virtual world setups (Foxman, 2019).

Moreover, Unity has a community supported by company together with willing participants, and that community provides many tutorials making it easier to learn. As in this study, Unity software free version can be downloaded for non-commercial uses. Today this software is used in many fields such as video game design, filmmaking, automotive, architectural visualization, interactive art production, simulator training and data visualization.

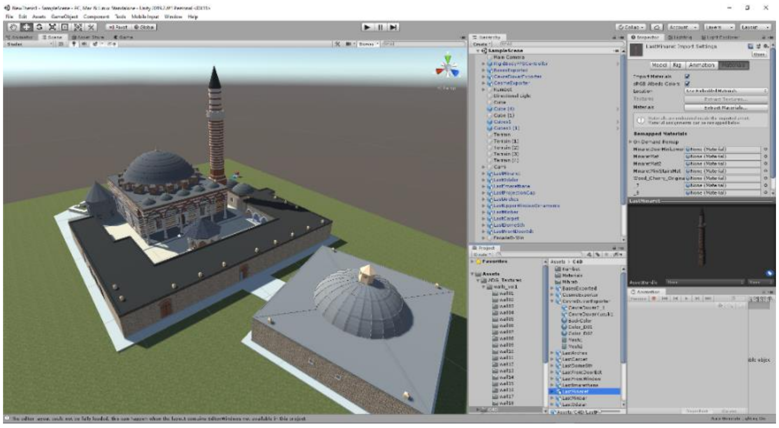

Figure 4.24. Unity game engine interface

4.5. Design and Development of Storytelling Presentation in Virtual Gaming Platform

This study is between gamification and serious games – it can be categorized as a gaming platform. Main aim of the study might be summarized as creating a virtual comprehensive interaction environment for users to learn by experiencing instead of giving raw information as a direct teaching method. In this study cognitive, affective and psychomotor learning methods will be combined to achieve a shift to experience-based representation and comprehensive interactions. In his article 'Games & Learning in Landscape Architecture' Marlow states that:

> Games can help design students gain a deeper and more comprehensive understanding of an issue by exploring the motivations and problems of the actors and environments involved. They offer more active discovery and less passive listening. They facilitate taking actions and feeling consequences. (Marlow, 2009, p. 236)

This study aims to reach not only students, but also anybody interested in architectural heritage. Horachek states 7 essential factors to be present in this kind of virtual platforms as:

- Immersion: Immersive games activate more meaningful comprehensive interaction pathways. Since human brain is able to store and solidify different types of information interconnected based on their relevance, by enhancing the experience with strong sensory inputs, outcome material intended to deliver might be transferred and retain more easily.

• Spatial learning: Human brain stores the mental map of surrounding environment and objects. Virtual platforms that have a component for spatial navigation naturally recruit that storage to facilitate experience development.

• Active learning: Virtual gaming platforms require active explorations beyond passive observation that makes them more conducive to gain knowledge. By using these platforms that have challenges, user is directed to participate and encouraged to have comprehensive interactions.

• Reinforcement and conditioning: For given scenarios, positive feedbacks for good behaviors of users increase the probability of repeating the same behavior when faced the same situation next time. User is not only rewarded by collectibles such as points, items or power-ups, but also by visual or auditory reactions such as celebrations with sounds and visual particle effects. These responses direct user to engage in positive and intended behaviors.

• Emotional attachment: The platforms that might build emotional attachment in users via their scenarios are used more actively, gains more attention. As user controls the character and guides character's actions emotional attachments are created and user perceives the character as an extension of the self.

• Cognitive flow: The state of flow is known as heightened state of engagement. In this state, brain works in higher capacities and exploration potential is increased. Virtual platforms as in this study encourage users to enter the state of flow by providing immersive experiences such as challenging the user to complete interesting achievements in scenarios with emotional pressure enough to keep user excited.

- Safe practice environment: Virtual environments in gaming platforms or real-time simulations are very good tools in experience development since they are inherently safe. Users are able to practice their skills inside virtual platforms without any risk of physical injuries, and they might repeat the same actions without physical boundaries which encourages explorations (Horachek, 2014).

In this study, all the 4D animations created using Cinema4D and Unity with their own sub scenarios will be combined in an interactive gaming platform created via Unity software, where users can experience and practice their knowledge gathered from these game mechanics, animations and other construction elements. Nevid defines motivation as the process that initiates, directs and maintains goal-oriented behaviors involving cognitive, social, emotional and biological forces which activate behavior (Nevid, 2012). To keep user motivated through that experience different game mechanics will be used in this study. With the use of game mechanics in the data and information transfer between individuals, this tool can be used to increase the knowledge about tectonics and raise an awareness of construction methods to teach the backstage of architectural end products. Intellectual effects of this method explained in detail in Chapter 5, hopefully will end up enabling participants to feel empathy with buildings. It is expected that user analyzes and internalizes the information provided in each platform which might guide future decisions in design and construction periods.

CHAPTER 5

METHODOLOGICAL FRAMEWORK AND ITS APPLICATION ON THE CASE STRUCTURE

This chapter is divided into two parts to better structure the interrelation between the methodological framework and its application on the case structure which is Hüsrev Paşa Mosque that will be examined in the second part of this chapter. Section 5.1 and its sub sections include the design principles of virtual gaming platform that might be applied on different cases independent from the Hüsrev Paşa case, on the other hand, section 5.2 and its sub sections include the application of the platform, described in section 5.1, on Hüsrev Paşa Mosque.

5.1. Design Principles of Virtual Gaming Platform

As immersion quality related high user expectations force the gaming industry constantly to pace up developments, gaming industry drives advancements in graphic performance in computer and other media technologies day by day. Graphic performance of computers keeps blurring the boundary between real and virtual environments, not only on static visualizations as photorealistic renderings but also in real time visualization and virtual environment creation (Pankiewicz & Hirschberg, 2015). In this study, a possible implementation of game technologies and mechanics in presentation of reconstructed architectural heritage in virtual environments is investigated. There are many examples of game technology use in architectural heritage today, but on the contrary to popular uses, focus of this study is to create immersive experiences and comprehensive interactions in virtual environments.

Horachek states that to design a virtual comprehensive interaction software for user experience, a framework should be developed, and that framework might be broken down into three systems as camera, character and controls which are:

- Camera: Camera system is the tool that arranges virtual cinematography in games which ensures 3D environment is shown in different aspects, and user experiences that environment in an interesting, dynamic and responsive way.

- Character: Character is a virtual 3D model of a person or virtual presence of sense organs that is controlled by user. That character represents the user in virtual environment and perform physical attributes to develop user experiences.

- Controls: This system is the layer that enables user to interact with the game environment and game objects. Control system might be in different forms correspondingly with the context and it might change in accordance with available hardware devices such as gamepads, motion tracking cameras or standard keyboard and mouse as in this study (Horachek, 2014).

In addition to that main framework, this platform includes interface arrangements to increase the quality of user experience as historical data references, texts, drawings, images and videos which enable user to investigate documented history of the structure or environment and analyze relations between them. According to Eastman, knowledge and experiences stored in memory becomes more accessible if they are interconnected with differentiable cues in people's minds and descriptive texts or words are good examples of these cues (Eastman, 2001). Because of the time limitation and scope of the study, surrounding environment and structures other than case structure were modelled with broad strokes to reference spatial urban context of presented time periods.

5.1.1. Design Elements of the Platform

Splash Screen

When the application is executed, a logo shows up for a few seconds to express commercial alliances or to show in game images while the user waits during the loading time. This screen might include a video or slideshow of photos belonging to the case with the name of it.

Figure 5.1. **Left:** The Long Dark splash screen, **Right:** Unity splash screen

Source: URL(50), URL(51)

Main Menu

Main menu is an essential part of gaming platforms that welcomes the user. This scene includes buttons to start or quit the application and change options with an attractive background.

Figure 5.2. Conceptual main menu design by Gustavo Carneiro

Source: URL(52)

User Guide

User guide gives instructions to user and stages the actions for a better experience. This guide includes information as “how the character moves”, “what interactions can be experienced” or “what the achievements are”. Since this kind of an application would aim to reach as many people as possible, user guide makes it possible to use by more people.

User View

There might be different view types according to the will of designer, but most common view types are first person view, third person view and omniscient or godlike view. In the first-person view, camera synchronizes with eyes of the controlled character and this allows user to experience the environment as present. In the third-person view camera follows user's character from a fixed distance to keep engagement with the character. In the omniscient or godlike view, a big portion of the scene is viewed from a faraway distance.

Free roam

In free roam, a weightless camera roams the environment with controls of the user to experience the environment free from gravitational boundaries. While the first-person view camera provides cognition of the virtual environment in human scale, people explore construction elements and their surroundings on a natural basis as a walkthrough experience. By switching to free roam, instead of construction elements, associations between constructed elements and structure groups might be perceived on a bigger scale.

Timeline

Timeline tool is used to control the specific time period of virtual environment and objects presented on the screen and experience the structure and environment in fourth dimension. User controls the timeline by chosen one of the predetermined time periods from the time bar. This feature enables user to experience virtual reconstruction of not only existing structure but also non-existing states of it reconstructed in reference to preservation documents.

Figure 5.3. Exemplary timeline design

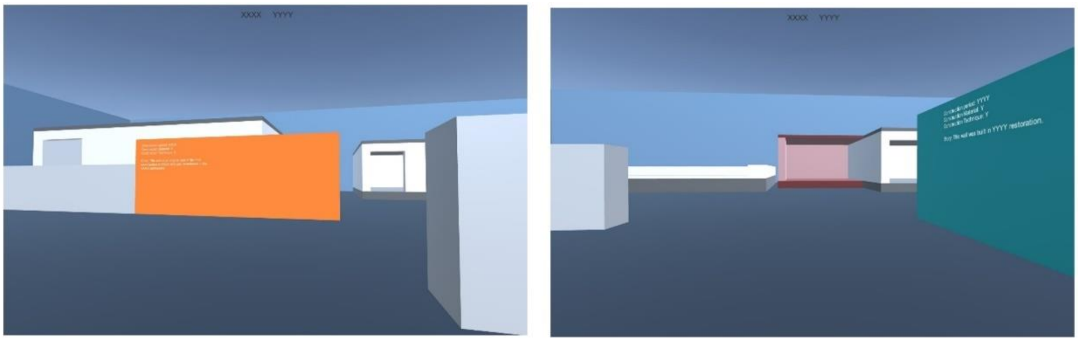

Figure 5.4. Physical structures from different timelines disappearance example

As in these exemplary visuals, when the user changes the timeline, physical structures belonging to this time periods appear or disappear in response to this action.

Diagrammatic Explanations

Diagrammatic scene enables user to investigate the case structure in schematic form with its changes throughout researched time period. With orbit, pan and zoom tools user can inspect individual parts dating different time periods from various point of views. This differentiation of time periods in diagrammatic scene is achieved by uniform coloring of building parts with respect to their construction dates.

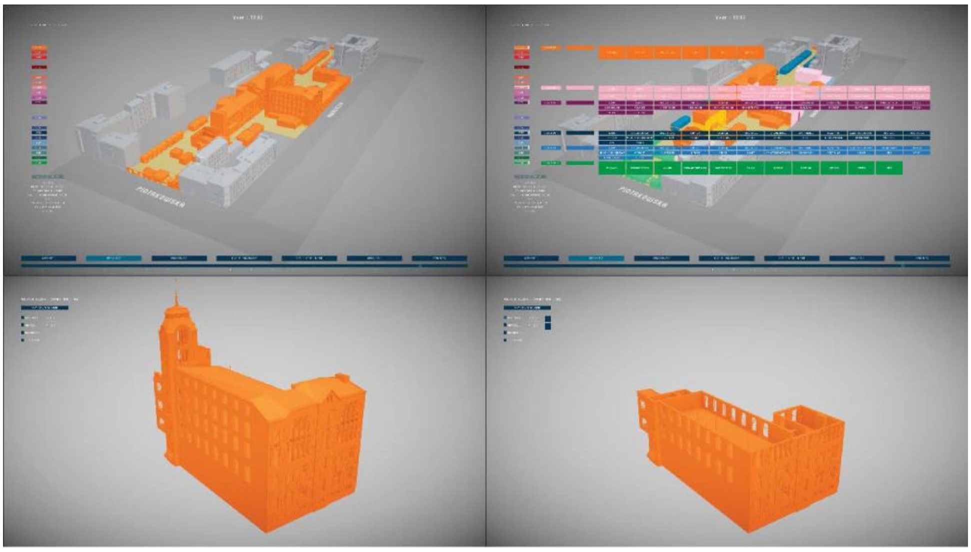

Figure 5.5. Diagrammatic analysis of a historical building (Pankiewicz & Hirschberg, 2015)

Mini Map

Mini maps are essential contents in almost every game. This tool is generally fitted on one edge and shows the current location of the character controlled by the user in the virtual environment for an easier navigation experience.

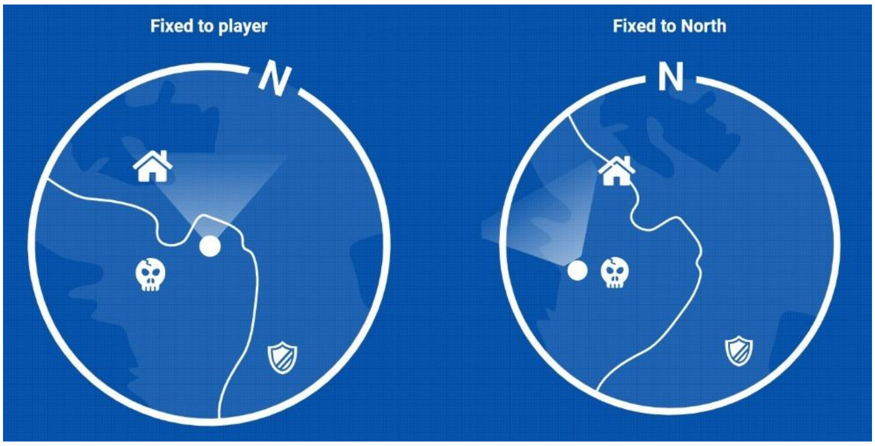

Figure 5.6. Mini map design examples

Source: URL(53)

Regional Map

As in this sample map image; icons for the building type, color codes for dates that buildings belong, another color code for building materials and icon overlays for the current situation of the building might be designed to make the structures, objects and environments more easily understandable.

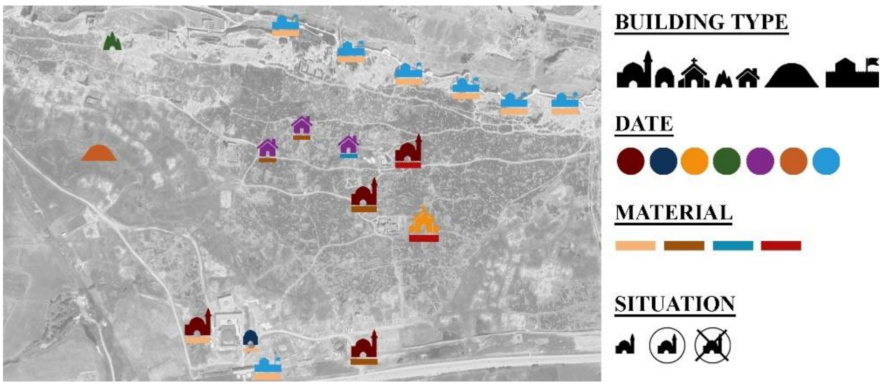

Figure 5.7. Exemplary regional map showing surrounding architectural heritage

Information Window

This tool gives information about building elements of structures by using text, image and animation. Windows pop up when an interactive object is clicked.

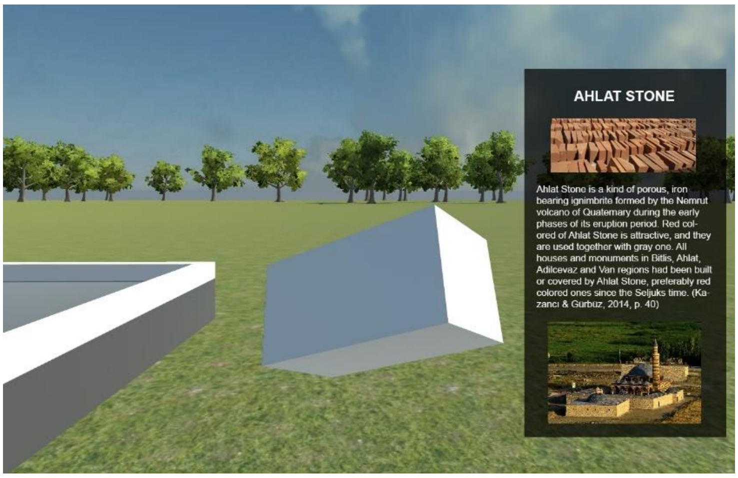

Figure 5.8. Conceptual design for information window

Achievements

Achievement systems can be defined as meta-tasks providing different goals independent from the main goal, as Hamari and Eranti states that achievements as goals in reward systems might be fulfilled through activities (Hamari & Eranti, 2011). This tool offers achievements to user for an interactive learning. User gets informed on his/her development on given task in an informative window.

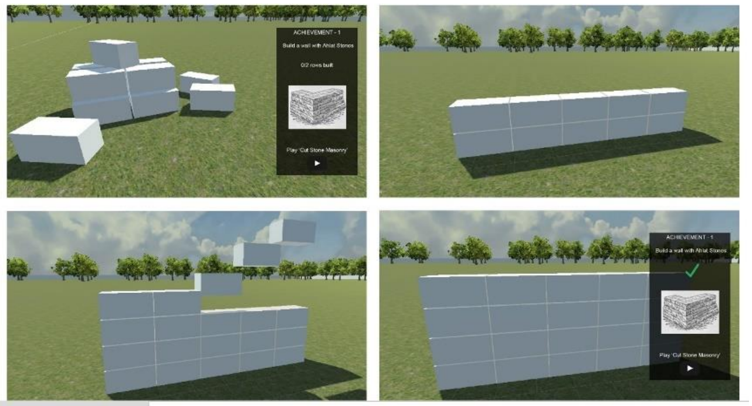

Figure 5.9. Conceptual design of a wall construction achievement

5.1.2. Validity and Application of Proposed Method to Better Understand Tectonics of Architectural Materialization in Architecture

Designers synthesize possible solution ideas responding different situations through their researches, investigations, and interactions (Reffat, 2007). As there are multi-layered design principles shaping conceptual ideas such as structural awareness, scale, detail, material, solid-void relationship, etc. there are also many different factors like experiences and prevision of designer affecting their way of creating, in the light of information brought by these principles. (Arat & Alkan Bala, 2015)

As mentioned before, dynamic developments in computer and game technologies make them more useful in the field of architecture day by day. Integration of these technological disciplines into architecture, makes it possible to better integrate digital and non-digital environments. As in this study, structures that are part of cultural heritage might not only be reconstructed as static figures, but also changes that they embraced throughout time might be told in a dynamic way. Presented conceptual ideas in this study makes it possible to envision future reconstructions of different structures and environments that could create a wholistic source of architectural knowledge to disseminate both in real and virtual environments. This kind of a comprehensive digital system, by creating a virtual learning environment, might be used as a powerful source of information for society to learn about past and create new perspectives on future (Pankiewicz & Hirschberg, 2015).

5.1.3. Possible Use of Proposed Presentation Method to Better Understand the Tectonics of Architecture in Education Efficiently

A main question for learner might be “how to understand tectonics in architecture?” and on the other side for education institutes this question might be shaped as “how to teach tectonics in architecture more easily?”. A key point here is trying to find better ways of teaching “how to perceive a structure and how to make construction of it compatible with architectural design or vice versa?” It might be said that a senseful balance between aesthetic and constructional concerns is needed in an architectural design to talk about tectonics in architecture. In architecture education materializing design ideas and creating architectural products needs a technical understanding integrated with foresight of people's emotions when they perceive tangible structures. This fundamental knowledge might be gained perceiving good examples of architectural masterpieces and analyzing their tectonic values.

In architecture studios, general teaching method is problem-based learning (PBL) or problem and project-based learning (PPBL). In this method, an imaginary design problem is created by instructor and students are expected to come up with a design idea to be used as a solution in the given task. (Zelina, 2000)

Students are expected to learn at each phase of the assignment as clarifying the problem, making decisions during design period and revise these decisions in development. This method is valid in artistic creations and enhances the use of developed methods and different approaches in each task. (Zelina, 2000)

The PBL and PPBL methodologies improve teaching. These methods motivate students to learn and think about problems and create alternative solutions for them. Each challenge of each problem leads students or learners to think and triggers their creativity in finding solutions resulting in enhancing their problem-solving abilities. Moreover, since these methods are applied to groups of students or learners and might require brainstorming in different occasions, they not only provide ability improvements in conceptual thinking of individuals but also it helps students or learners to build their teamwork skills. Of course, all these positive advancements might need some directive encouragement from institutions and these institutions might be replaced as narrators in our gaming platform.

Analyzing built structures on different medias, especially the ones creating visual environments and simulating real world experiences like subject of this study might be a practical method to create solutions for exemplified problems. This experience is reinforced with interactions and imaginary dialogues between users and experienced objects or structures. This interaction leads an active and direct education, moreover when the knowledge gained from this interaction is combined with creativity promoted in architecture education, new solutions may occur way easily, and this end product may bring new developments along with it.

One of the most important necessity in architecture education is curiosity of student. Students need to think about the task and have an individual attitude towards it. In a well-structured education system this curiosity increases correspondingly with architectural knowledge in each semester, and this willingness should be supported by each member of education system including instructors. In the light of this information, it can be said that the more architecture education encourages a student to self-study in a creative way the more successful and self-sufficient architects graduate.

End product created in this study tries to encourage architecture students to think and create successful solutions to design problems through experiences by the help of technological creative tools.

5.1.4. Possible Use of Proposed Presentation Method in Architectural History Preservation

At this point again works of Reo-Tek can be very good and inspiring examples as a starting point of this study. In their visual installation for ITB Berlin 2018 (International Tourism Biennale), Reo-Tek created a scientifically correct 3D model of ancient city of Aphrodisias located in Aydın, Turkey to introduce and promote the region. The project was supported by not only Kuşadası Municipality but also Ministry of Culture and Tourism General Directorate of Promotion. It is not easy for everyone to imagine ancient times of the city by looking at the ruins, so this installation consisting of 3D model and 4D animations to give opportunity to witness the ancient situation of the city for the users in a virtual environment.

This virtual environment was offered to be experienced in a modern technological media which is called Magic Box that uses inner surfaces of a box that manipulates the images to be perceived as the user stands inside the created virtual environment and surrounded by it. This media tool allows multiple users to have the same experience at the same time and removes the need of a VR headset.

Figure 5.10. Scene 1 from virtual model of Aphrodisias

Source: URL(54)

Figure 5.11. Scene 2 from virtual model of Aphrodisias

Source: URL(54)

As an example to the use of games in prevention of historical knowledge, a partial installation of Reo-Tek's Kayseri Seljuk Civilization Museum project can be analyzed. This installation aims teaching the recipes to produce Seljuk medicines in a virtual environment. Users experience the production by adding herbs and other extracts in correct amounts to achieve making the medicine that is written in the recipe book.

Figure 5.12. Medicine recipes of Seljuks in virtual environment

Source: URL(55)

As emphasized in the study, this new experience-based storytelling presentation technique might be used on recreation or representation of case historical buildings in a virtual environment. First, this requirement of method might give rise to gather a new virtual collection of structures with historical value, and for a better atmospheric cinematographic experience urban life might be examined and represented in these platforms. Second, this method might revive or at least keep a record of many long forgotten traditional construction techniques and materials. These traditional construction techniques might be modernized with today’s technology and might lead to research and development activities and innovations in architecture. Third, as currently used animations and virtual tours created for historical monuments, this method might direct people’s attentions to many valuable structures sinking into oblivion.

5.1.5. Alternative Programs to Develop an Online Architectural Network to Share Knowledge of Tectonics in Architecture and Architectural History

Architectural practice adopted almost all computational methods in past decades and with this adoptions, architectural records and work files such as CAD drawings, 3D models and visualization files might be exchanged between actors from different time zones and become an end product of a collaborative work of many AEC related people including architects, engineers or consultants. This transportation of digital information does only require a digital movement of coded files. Globalization process in practice of architecture forced the pace of this transformation and today architectural discipline has already become a multidisciplinary and collaborative profession with each development in industries of information technologies (Al-Saati, Botta, & Woodbury, 2000).

A new methodology that is considered as an end product of the study might be applied on historical buildings and as in the example of studies on 4D presentation techniques on historical buildings, there is an archetypal documentation project named Anqa Project on architectural documents and sites that is possible with a collaboration between ICOMOS (International Council on Monuments and Sites), California NGO CyArk, Yale IPCH (Institute for the Preservation and Cultural Heritage) and Syrian DGAM (Directorate-General of Antiquities & Museums). Anqa Project's driving force is shared in this study, but this method hopes to take previous projects a step further by gamification and teach while digital experiences. Moreover, this study is interested in not only visuals of physical structure but also tectonic knowledge that can be gathered from these monuments. With the help of this method, the knowledge about architectural heritage can be transferred through generations with minimum loss of information to learn from them in a safer environment (Sayer, 2016).

As another example, there is an up to date project named Timeline Travel that shares similar concerns and interest with this study. Timeline Travel is an interdisciplinary and international project developed by twenty academics from different fields, supported by Erasmus+ Program of the European Union and coordinated by architectural historian Asst. Prof. Muzaffer Özgüleş. The project is defined as a digital application that makes history of architecture more enjoyable and easier to learn for both academics and students. Timeline Travel uses the website "timelinetravel.net" to be accessed and that website includes a map on which architectural heritage locations appears and disappears correspondingly with the timeline chosen from a slider that includes construction dates as pinpoints. When a pinpoint is clicked on the map or timeline, a pop-up window appears including images, historical data and sources of reference of that structure. The project aims to become a self-learning web platform and an online data source of architectural heritage with future developments (“Timeline Travel”, n.d.).

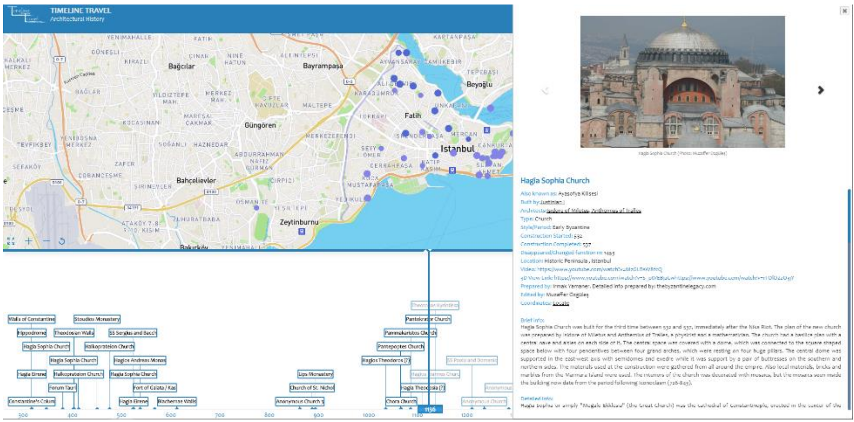

Figure 5.13. Timeline Travel Project

Source: URL(56)

Later developments on presentation and representation tools together with informative cataloguing systems for cultural heritage protection made these applications more integrated and interoperable. As a result, configuration of this kind of applications and harmony between these technologies makes easier data transfer and knowledge sharing possible in a global scale (Fiorino & Loddo, 2015). Instead of creating mere singular applications, a complex network of different cases from different parts of the world might be created as a next step of this study. Database of architectural and cultural heritage might be transformed into this kind of improving active tools to prevent dissolution of existing knowledge by sharing it. A network as stated would allow easy access to data and more effective management of it, moreover with collaboration of people from different backgrounds with similar aims on a connective platform might make way for explorations on architectural heritage or create a better understanding of it for non-expert people.

Since the new experience-based presentation technique will use 4D architectural animations on a case historical building, another important use of this method may be reviving many traditional construction techniques which are forgotten up to now. Traditional construction techniques might be visualized with their construction phases and these revived traditional construction techniques with developing technology might enable research and development activities that can lead to innovations in architecture.

5.2. Application of Animated Storytelling Presentation Technique on Hüsrev Paşa Mosque by Mimar Sinan as a Case Structure

Figure 5.14. Hüsrev Paşa Külliyesi

Source: URL(57)

In architectural practice, envisioning heritage was concentrated on visual aesthetics and preserving the image primarily. This image-oriented preservation understanding lasting for centuries is valuable since it reflects cultural values and foundational past of communities, but studies today investigate relationship between architectural heritage and their cultural context with a systematic approach (Bussiere, 2015).

Architectural heritage is an important part of cultural heritage and it constitutes self-consciousness of society, in this manner, preserving architectural heritage concerns both past and future of communities. Heritage preservation needs collaboration of people in society and awareness of its importance depends on a common knowledge of community. To reach as many members of society as possible, both experts and non-experts, owned information about protected and lost heritage should be rendered in people's mind (Koszewski, 2015). This attempt might be possible by effective use of a digital concept as emphasized in this study.

5.2.1. Historical and Architectural Analysis of Hüsrev Paşa Mosque: Traditional Construction Techniques and Knowledge of Local Materials

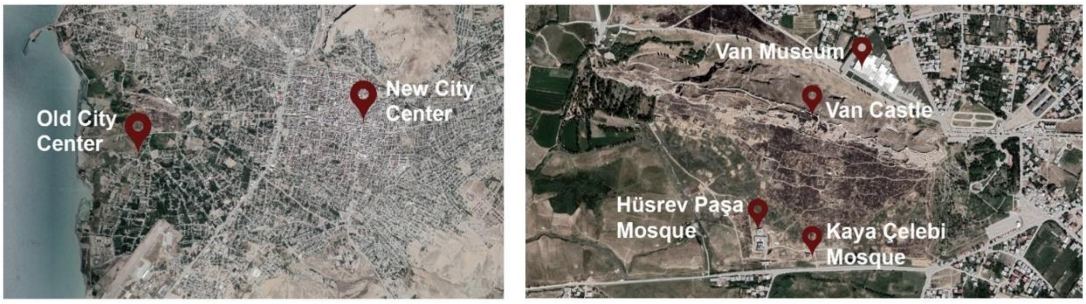

Figure 5.15. Google Earth image of old city center of Van

Source: URL(58)

As introduced in the official website of Ipekyolu Municipality, Hüsrev Paşa Mosque is located in the old city of Van around Van Castle and it is the center of an Islamic-Ottoman social complex, Hüsrev Paşa Külliyesi ("Hüsrev Paşa Külliyesi." n.d.). The old city of Van was substantially ruined in World War I and new settlements of the city was built 5 km away from previous one. After this time the old city was abandoned, and many historical buildings were destroyed in a very short period of time including Hüsrev Paşa Mosque.

This complex consists of madrasa, fountain, tomb, almshouse and mosque designed by Mimar Sinan in 16th century in old city of Van and was mainly ruined until recently (“Hüsrev Paşa Külliyesi.” n.d.). In the Encyclopedia of Islam, Prof. Dr. Semavi Eyice gives general information about the mosque. When his studies are analyzed, it can be said that Hüsrev Paşa Mosque, known as Kurşunlu Mosque was built by Hüsrev Paşa The Governor of Van during sultanate of Murad III. 1567-68 is the written date of construction of the mosque on the epitaph signed by the name ‘Yûsuf’. Hüsrev Paşa Mosque and Madrasa, is listed in ‘Tuhfetü’l-mi‘mârîn’ as Works of Mimar Sinan. This situation is confounding and is not settled yet. Even if this mosque and madrasa is from Mimar Sinan’s works, he could not have come this far to construct these structures. As in the example of Murâdiye Mosque in Manisa, these structures could be built by one of Sinan’s master-builders sent to Van by him. (Eyice, 1999)

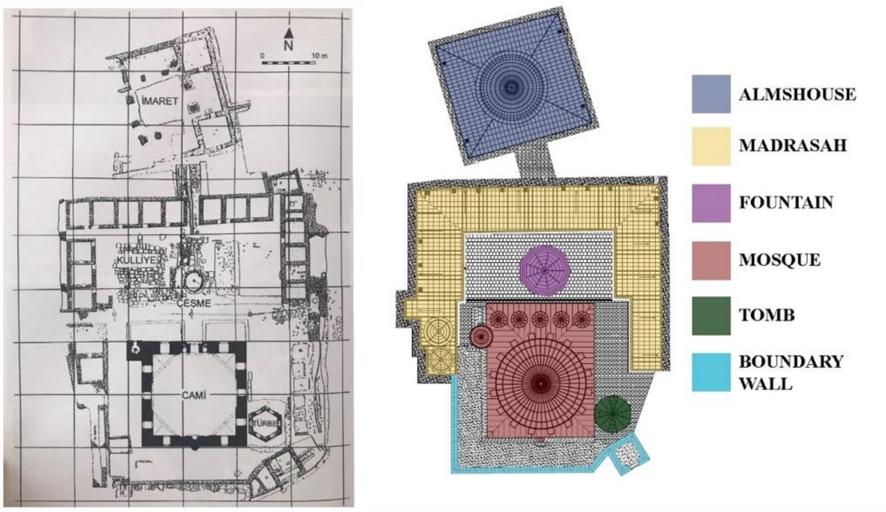

Figure 5.16. Site plan of Hüsrev Paşa Islamic-Ottoman Complex (Kılıç, 2006)

Hüsrev Paşa Mosque was abandoned until 1975. In 1975, architect, restoration specialist and architectural historian Orhan Cezmi Tuncer conducted a rehabilitation Project for the mosque and at least kept it alive until a restoration project. In 1996 Prof. Dr. Abdusselam Uluçam leaded a conservation and restoration project for the site and unearthed madrasa and some other parts of the complex. In 2007 another restoration project was done by Güzel İnşaat ve Ticaret Partnership and carried out by

Van Yüzüncü Yıl University that was completed in 2008 and the mosque was brought into use. Three years later, in 2011 the mosque was damaged in the earthquakes, minaret and portico courtyard of the mosque was harmed. The latest restoration project was prepared by CLM Architecture and carried out by Bitlis Regional Directorate for Foundations that started in 2012 and completed in 2015 and due to structural weaknesses, 8 of drum windows were bricked in (Altunışık & Genç, 2017).

After the first rehabilitation project conducted by Orhan Cezmi Tuncer, Van Provincial Directorate of Culture and Tourism makes a research on architectural features of the mosque present for that day and states that portico courtyard on the northern side of the square plan and domed mosque is ruined. Sanctuary is composed of thick walls and with a dome on these walls. Walls are made of cut stone, squinches and dome is made of brick. Ceramics covering inside walls does not exist today. Entrance is placed in a cove on the north facade. Windows create dynamism on the facades. Two different colored cut stone materials are visible on minaret and exterior walls. Balcony, upper body and spire of cylindrical minaret with square pulpit rising on the northeast corner is repaired. In the interior, mihrab placed in the center of qibla wall is attention grabbing. Rectangular mihrab is made of limestone with a well craftmanship, crowned with trefoil arch, and it has pentagon muqarnas kavsara niche. There are geometrical ornaments on mihrab. Unfortunately, mihrab was vandalized by treasure hunters in 1992, moreover very few of hand carving and ceramics are left. (Hüsrev Paşa Camii, n.d.)

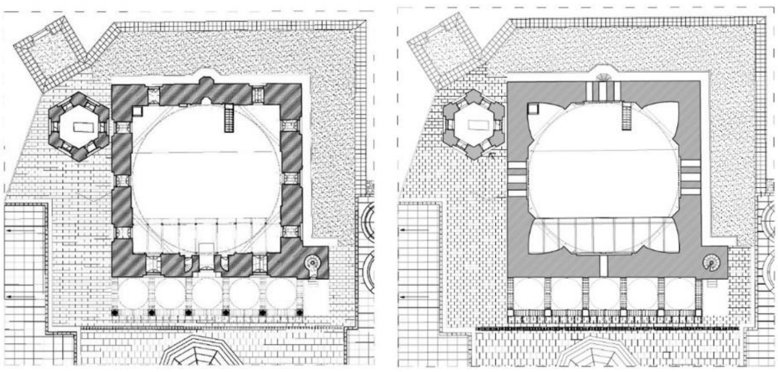

Figure 5.17. Floor plans of Hüsrev Paşa Mosque

Prof. Dr. Semavi Eyice states structural features of the mosque as:

> Mosque is built using light and dark two different colored uniform local stones. A big dome with supporter buttresses covers square planned space and dome cup. Window openings on the dome cup light the interior. On the facades, there are lancet windows on the lower rows. Upper row windows found in many classical mosques does not exist in this one. On the other hand, as a novelty on the upper parts of each façade, there are three small windows with the middle one higher than other two. Mihrab projects from the wall as a small cornered projection.
>
> On the entrance façade, ornaments of main door, decorations surrounding epitaph and guilloche motive are stranger to Ottoman arts. There was no sign of ceramics covering interior walls before, only their traces on plaster. Some ceramics were found in debris used to close lower floor windows, some hexagonal pieces of ceramics were cleaned and are under protection in Van Museum. Although it was heyday of Ottoman-Turkish ceramic art during the construction of mosque, ceramics used here were not so vulnerable in technic and color, they might not be brought from İznik an important center of ceramics but made in somewhere in Southeastern Anatolia maybe Diyarbakir. There is no sign from mihrab, minbar, gathering place, chandelier and colored glass stucco windows that Evliya Çelebi writes about beauty and grandness of them. According to Uluçam, Mihrab with tripartite kavsara stranger to Ottoman style, was ruined in 1992 with dynamite by treasure hunters. Thick bodied minaret is made of rows with equal thickness using two different colored uniform local stones (Eyice, 1999).

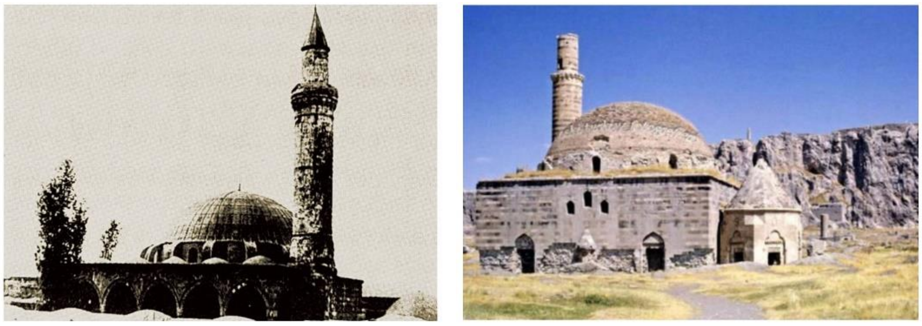

Figure 5.18. **Left:** Hüsrev Paşa Mosque in early 1900s, **Right:** Hüsrev Paşa Mosque before partial restorations in 1975

Source: URL(59), URL(60)

Figure 5.19. Hüsrev Paşa Mosque after partial restorations in 1975

Source: URL(59)

Figure 5.20. **Left:** Hüsrev Paşa Mosque in 2008, **Right:** Hüsrev Paşa Mosque after 2015 restoration

Source: URL(60)

5.2.2. Ahlat Stone as Main Structural Material

As in any other region natural stones play an important role as natural construction materials in historical buildings of Anatolian region. Natural stones like marble, limestone, andesite and ignimbrite were used in many historical buildings starting from long before written history since they were easy to obtain. Today even if natural stones are not widely used as they were before modern construction techniques were discovered, they are still an important part of architectural knowledge and find their places in many buildings with high architectural value. They are generally used as cover materials or in construction of partition walls more than as load bearing elements in modern buildings; or as landscape elements like pavements.

Hüsrev Paşa Mosque is one good example of stone masonry structures in region. Its structural material Ahlat stone is a well-known local material and is used in many historical buildings in nearby cities. As stated by Kazancı and Gürbüz in Geological Bulletin of Turkey,

> Ahlat Stone is a kind of porous, iron bearing ignimbrite formed by the Nemrut volcano of Quaternary during the early phases of its eruption period. Red colored of Ahlat Stone is attractive, and they are used together with gray one. All houses and monuments in Bitlis, Ahlat, Adilcevaz and Van regions had been built or covered by Ahlat Stone, preferably red colored ones since the Seljuks time. (Kazancı & Gürbüz, 2014, p. 40)

Figure 5.21. Ahlat Stone

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Ahlat stone is well-known in the region because of its use in religious structures like tombs, madrasahs, mosques and especially tombstones in Ahlat Seljukid Cemetery in Bitlis.

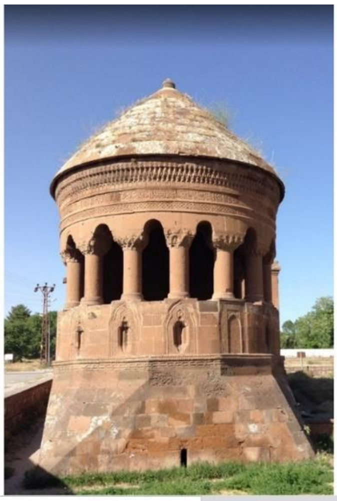

Figure 5.22. **Left:** Tombstones in Ahlat Seljukid Cemetery **Right:** Tomb in Ahlat Seljukid Cemetery

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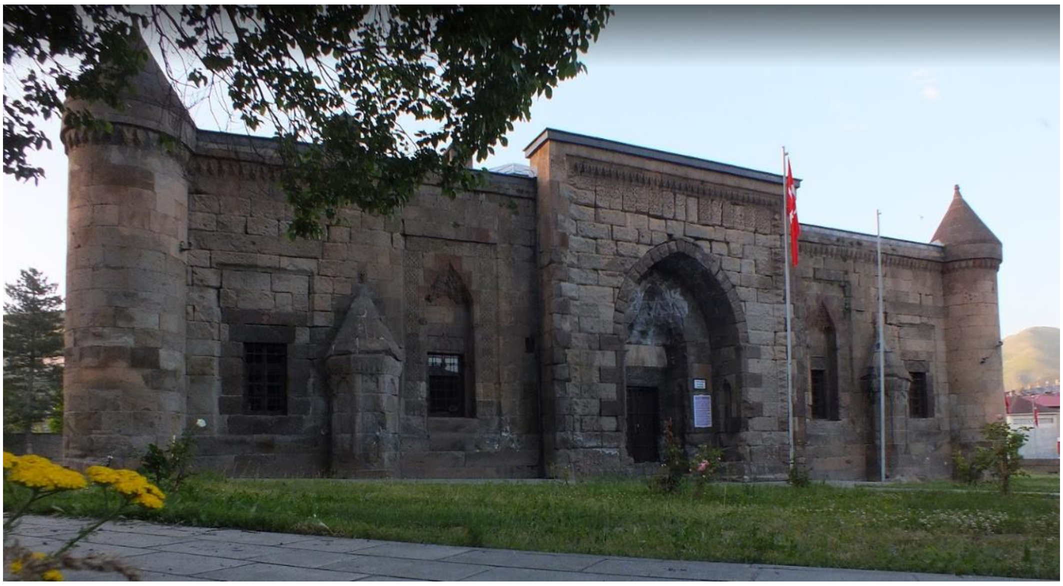

Figure 5.23. Ihlasiye Madrasah currently housing Bitlis Regional Directorate for Foundations

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5.2.3. Conventional Presentation of Materialization and Tectonics of the Case

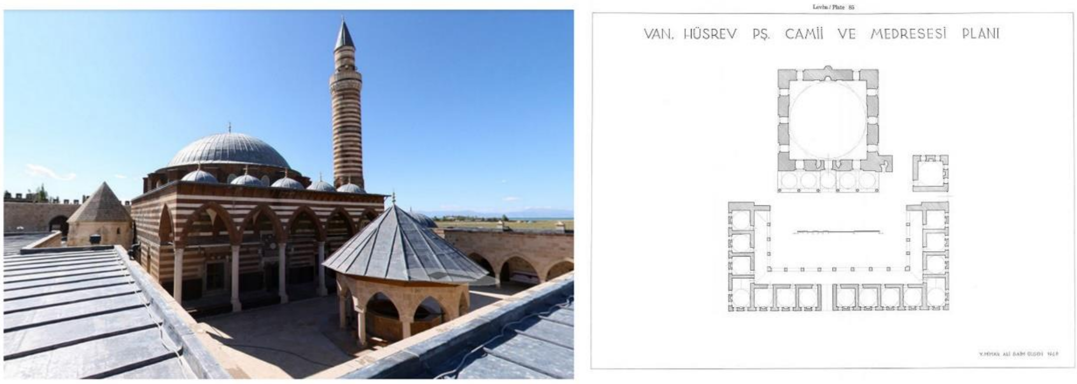

Figure 5.24. **Left:** Hüsrev Paşa Mosque, **Right:** Hüsrev Paşa Mosque and Islamic-Ottoman Complex plan by Ali Saim Ülgen

Source: URL(65)

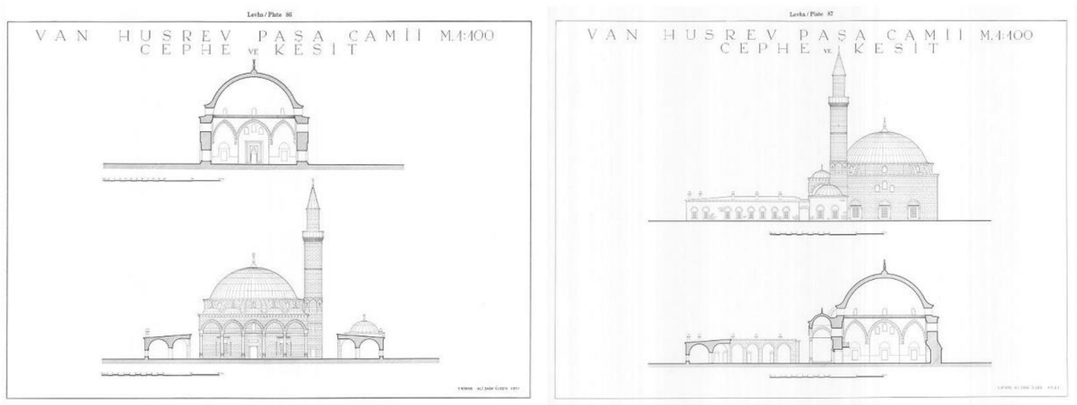

Figure 5.25. Hüsrev Paşa Mosque 2D section and elevation drawings by Ali Saim Ülgen

Source: URL(65)

When Şahabettin Öztürk's studies in 1996 are examined to understand the situation of mosque and social complex, it can be said that all other parts of social complex except from tomb and mosque were totally ruined until that period of time. Portico courtyard of the mosque was also ruined to ground, only traces of its five domes made of brick were visible on the northern facade walls of the mosque. (Öztürk, 1996)

*Following examinations are taken from Şahabettin Öztürk's studies in 1996

Interior

Hüsrev Paşa Mosque is designed and built with a 15.19 x 15.32 meters square plan. Entrance to indoors is from a 1.49 meters wide door located on portico courtyard on north façade. Thickness of main walls of structure is 2.30 meter on north façade, and 2.10 meters on east, west and south façades. There are 1.35 meters wide opposing windows two on the north and south, and three on the east and west façades facing each other.

There are 0.73 meters wide spiral stairs to gathering place on both sides of entrance door, but gathering place is totally ruined and does not exist. 3.30 meters wide mihrab, located in the middle of southern wall facing the entrance, is made of white limestone. 1 meter wide and 0.65 meters deep carved 5-sided mihrab alcove is crowned with a trefoil arch supported by rounded pillars. There are infinite geometric ornaments as a belt around mihrab, thinner on top and wider on sides. A row of muqarnases frames mihrab from the outside after this belt and place between that frame and trefoil arch of mihrab is ornamented with plant motives hand carvings. Kavsara and plinths of mihrab is ruined by treasure hunters in 1992.

Dome of the mosque covering the interior has a diameter of 14.60 meters. Transitions between dome and lower parts is achieved by squinches, and load is transformed to main walls by the help of eight pointed arches. Dome and squinches are made of bricks. Bottom parts of dome are framed with two rows of eaves. Lighting of interior is provided by not only 10 lower windows on the main walls but also 16 pointed arch windows on drum, 0.75 meters wide triplet windows on east, west and north façades, and one single 0.75 meters wide window on south façade. There is a leveling of 0.25 meters on the ground inside. Wall surfaces are covered with lime, but most of this covering is ruined. Walls were covered with glazed tiles 2 meters high, but these tiles were removed to Leningrad Museum during Russian occupation.

East and West Façades

East façade is 19.60 meters wide. The wall on this façade is 0.56 meters and elevation difference between ground corners is 0.05 meters. 3 rectangular windows are framed with pointed arch alcoves made of white and brown colored stones and these arches create rounded wall piers on window corners. Windows are built as stones sitting on a monolithic lintel stone and tympanums are ornamented with single row of muqarnases.

There are 0.70 meters wide triplet upper windows on top of the middle window. Fascia is used as transition between lower parts and upper covering of the structure. Because of structural insecurities, dome is supported with a 2.56 meters tall drum in 1968 restorations. To protect this drum and dome, 16 flying buttresses, each 1 meter wide and 1.50 meters tall, are placed around the drum. 16 of 0.75 meters wide windows covered with pointed arches on top of them are placed on drum with equal intervals. Fascia is again used for transition between drum and dome with a slope between them. West façade has the same physical characteristics of east façade since they are symmetric to each other except some minor differences. Tympanums are ornamented with muqarnases and middle row of muqarnases is above other two side rows. Finally, monumental minaret rises on the northern corner of this façade adjacent to it.

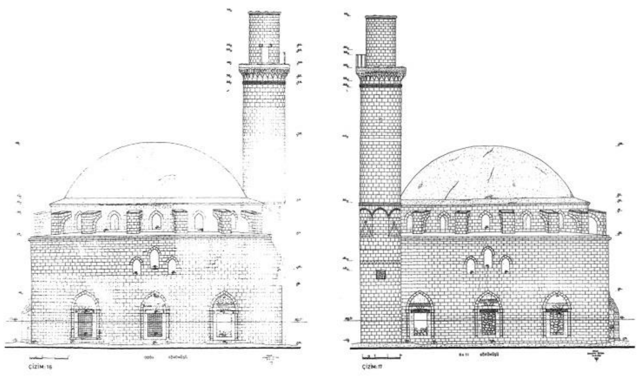

Figure 5.26. East and West Elevations of Hüsrev Paşa Mosque in 1996 (Öztürk, 1996)

South Façade

South Façade is 19.25 meters wide. Mihrab creates a 5-sided projection in the middle of this façade. Both windows on two sides of this façade has the same characteristics of other side windows on other façades. After rising for 2.50 meters mihrab projection ends with a half pyramidal cone and that cone is ruined by treasure hunters in 1992. There are triplet windows located above mihrab.

North Façade

Portico courtyard of the structure located in this façade is totally ruined, only visible remains are traces of pointed arches of 5 domed covering on top of portico courtyard. Pointed arches are made of bricks. 1.49 meters wide entrance door of the mosque is placed on this façade, and this door is surrounded by a pointed arch. Two different frames one for geometrical motives and one for historical epitaph couplet is placed on top of the door. Between epitaph frame and pointed arch there are ornaments of branches, leaves and fruits spreading through both sides from a vase. There is a single window on the pointed arch surrounding entrance door. On both sides of the entrance there are windows similar to side windows of other façades and muqarnas ornaments of these windows are in two rows. Five rows on top of windows are partly ripped. Cut stones used in every façade are in different dimensions. In 1968 partial restoration, a local material with lower durability, Ahlat stone is used in white, brown, grey and red colors in an alternating pattern.

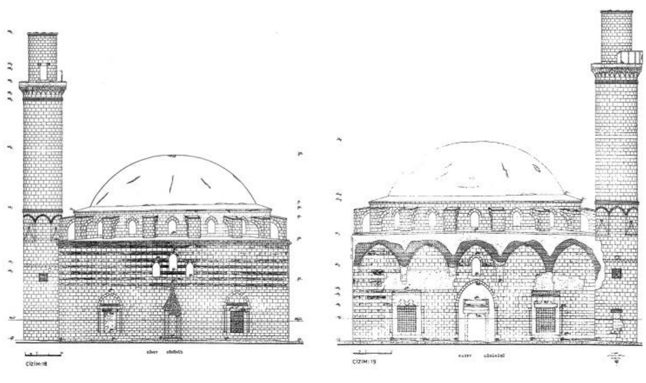

Figure 5.27. South and North Elevations of Hüsrev Paşa Mosque in 1996 (Öztürk, 1996)

Minaret

Square planned minaret with 3.2 x 3.2 meters dimensions is built adjacent to the northwestern corner of the mosque. Entrance of the minaret is from a 0.65 meters wide door on its north side, but right and lower sides of door is ruined. Minaret rises for 8.5 meters from ground maintaining its square plan, after that a transition consisting 1.3 meters tall chamfers and octagonal pointed arches is used before higher part of minaret that continues with a cylindrical body.

Cylindrical body is 10.10 meters tall and has three embrasures on it. There are different continuous geometrical ornaments around minaret on +4.80, +9.40, +14.45, +18.85, +24.00 levels. There is a 60 centimeters wide door facing east used as passage from minaret to roof of mosque on +6.67 level of minaret. Diameter of cylindrical minaret is 3.24 meters, wall thickness is 0.80 meters, stairs width is 0.55 meters and diameter of pillar is 0.28 meters. With muqarnases cylindrical body expands for 0.90 meters in diameter and creates minaret balcony with a 0.60 meters wide door on the south. Balustrade of minaret balcony is 0.15 meters thick and 1.05 meters tall. Upper part of the minaret body with 0.55 meters wall thickness above minaret balcony rises for 4.18 meters and ends with a belt of muqarnases.

On north, west and south façades and +3.35 level of minaret there are 0.65 x 0.65 meters wide epitaphs with cufic ornaments. Some parts of western façade, minaret balcony muqarnases, most of minaret balcony balustrade and all of spire are ruined. Minaret is 26.03 meters tall from ground to belt of muqarnases above upper part of the minaret.

Figure 5.28. Minaret of Hüsrev Paşa Mosque

5.2.4. Application of the Proposed Presentation Method to Present the Tectonics of Hüsrev Paşa Mosque in A Virtual Environment via Unity with Additional Motion Based Animations Prepared in Cinema4D

In this part, previously designed presentation method is applied on Hüsrev Paşa Mosque with placement of informative animations inside virtual representation of Hüsrev Paşa Mosque and its environment.

Splash Screen

In the splash screen of application created as an end product in this study, Unity logo shows up for a few seconds to express that the software version used in the application is procured with a free to use license. This screen is not optional in a free version, so it is not a part of the design, but this information is given as a brief to the user.

Figure 5.29. Unity free version splash screen image

Main Menu

Main menu welcomes users with a visual of Hüsrev Paşa Mosque and includes "GET IN!" button that starts the experience, "OPTIONS" button that changes settings of the platform, "ABOUT" button that gives information about platform and "QUIT" button that ends the experience.

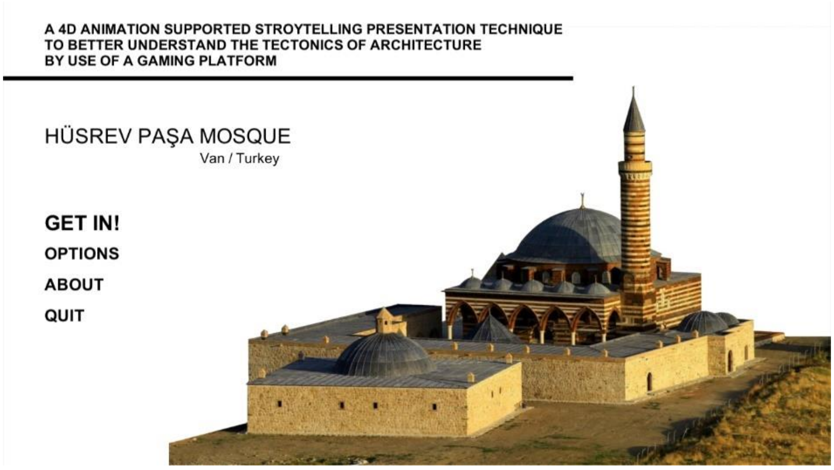

Figure 5.30. Main menu for Hüsrev Paşa Mosque's virtual gaming platform

Construction Animations

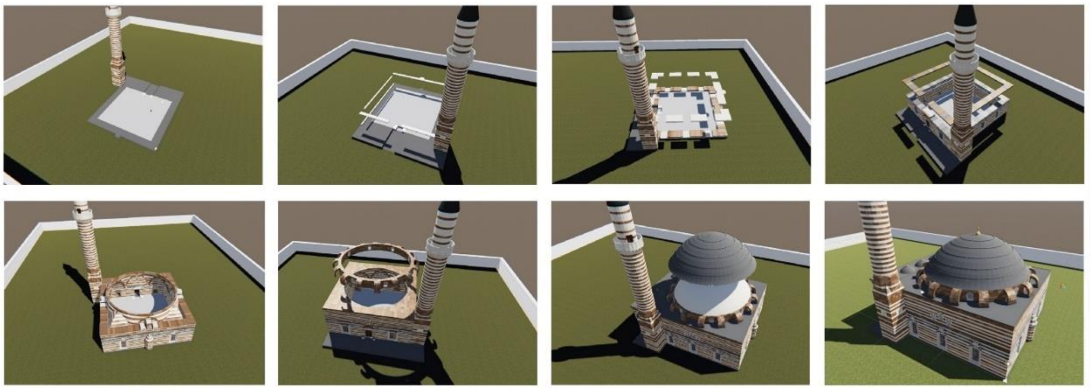

Figure 5.31. Birds eye construction animation of Hüsrev Paşa Mosque

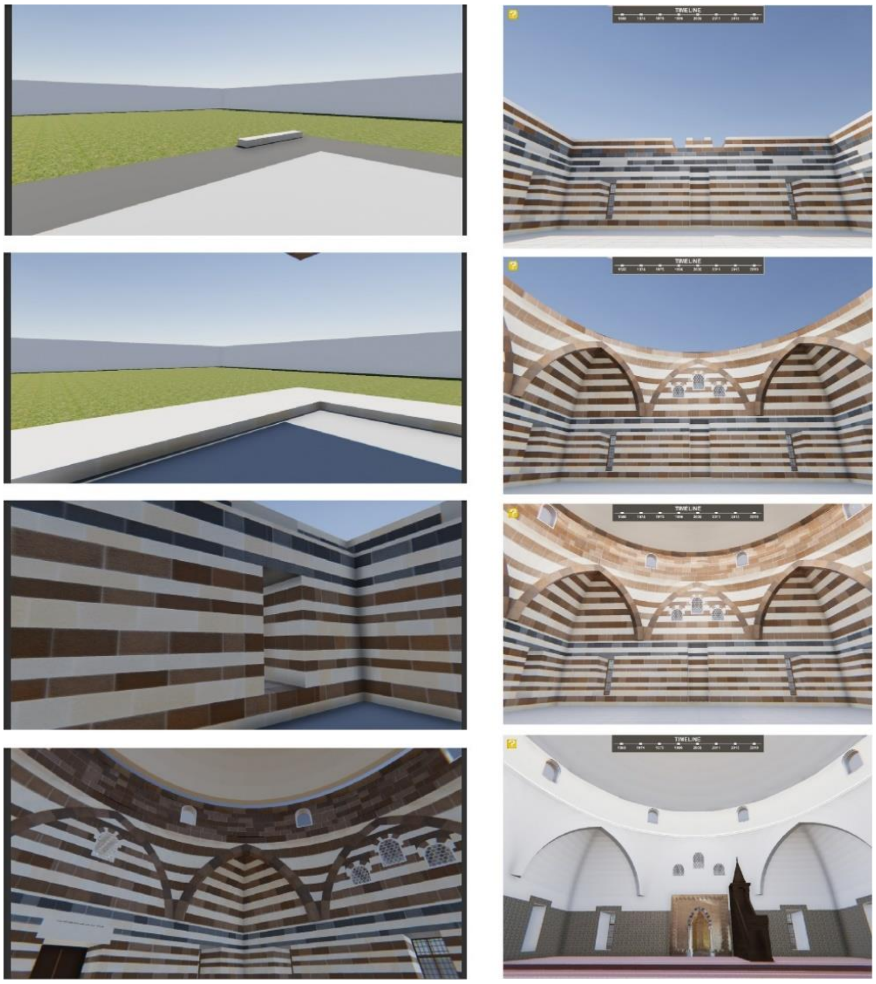

Figure 5.32. First person view construction animation of Hüsrev Paşa Mosque

User Guide

Since this study aims to create a common ground for people from different fields of interest to develop experiences in a comprehensive interaction environment, a user guide is needed to help user navigate in the virtual platform more easily. As in almost any game, this user guide gives instructions to user and stages the actions for a better experience. In this application, user guide includes information abouts navigation tools, mode choices and timeline.

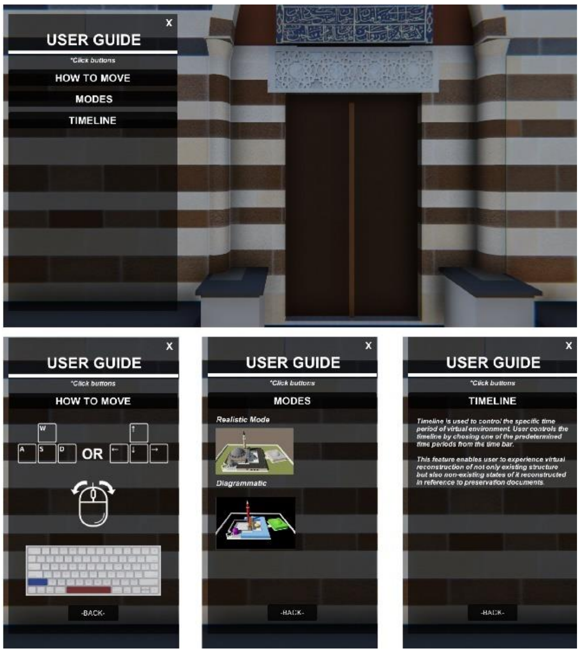

Figure 5.33. User guide panel for virtual gaming platform

Free roam

When the “R” key is stroked, a camera on top of controlled character gets activated and roams with controls of the user to experience the environment free from gravitational boundaries. While the first-person view camera provides cognition of the virtual environment in human scale, people explore construction elements and their surroundings on a natural basis as a walkthrough experience. By switching to free roam, instead of construction elements, associations between constructed elements and structure groups might be perceived on a bigger scale.

Birds Eye View

When the “B” key is stroked, camera synchronizes with a point on the back of a bird controlled by the user and this camera follows this bird from a set distance. This feature allows user to experience the environment with a third-person view.

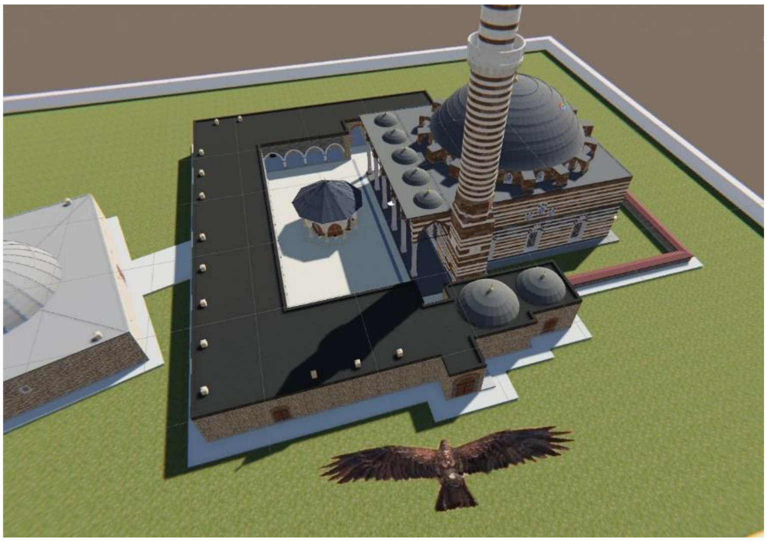

Figure 5.34. Birds eye view of Hüsrev Paşa Mosque

First-Person View

When the “F” key is stroked, camera synchronizes with eyes of the controlled character and this allows user to experience the environment with a first-person view.

Figure 5.35. First person view of Hüsrev Paşa Mosque

Figure 5.36. First person spatial experience

Timeline

Timeline tool is used to control the specific time period of virtual environment and objects presented on the screen and experience the structure and environment in fourth dimension. User controls the timeline by chosen one of the predetermined time periods from the time bar. This feature enables user to experience virtual reconstruction of not only existing structure but also non-existing states of it reconstructed in reference to preservation documents.

Figure 5.37. Timeline panel

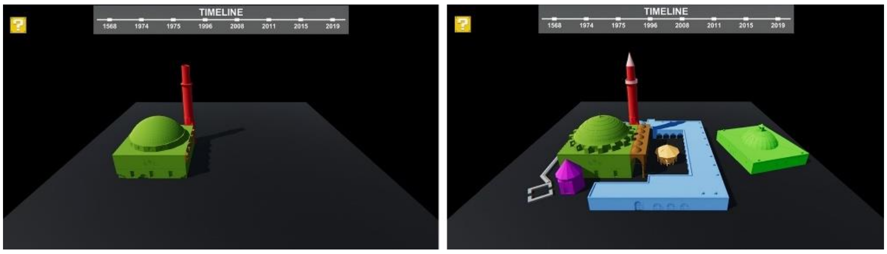

Figure 5.38. Diagrammatic analysis of time periods

Diagrammatic Explanations

Diagrammatic scene enables user to investigate the case structure in schematic form with its changes throughout researched time period. With orbit, pan and zoom tools user can inspect individual parts dating different time periods from various point of views. This differentiation of time periods in diagrammatic scene is achieved by uniform coloring of building parts with respect to their construction dates.

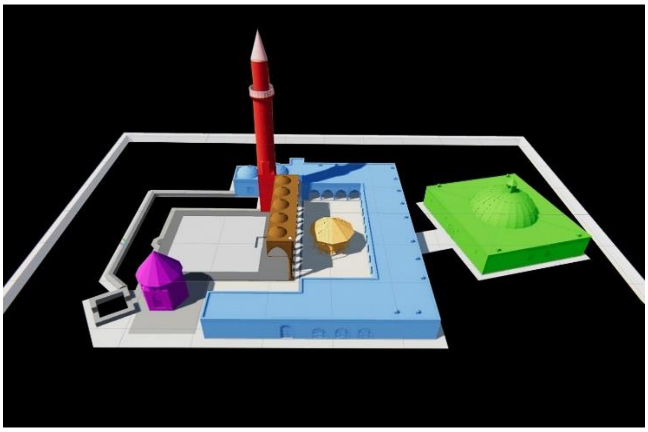

Figure 5.39. Diagrammatic Analysis

Mini Map

Mini map is fitted on bottom right corner and shows the current location of the character. This tool increases the spatial awareness by using a camera fitted on top of the user that follows character's actions and informs user about the surrounding objects.

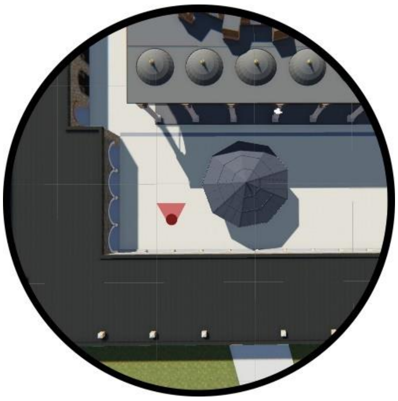

Figure 5.40. Mini map for Hüsrev Paşa Mosque

Regional Map

As in this sample map image; icons for the building type, color codes for dates that buildings belong, another color code for building materials and icon overlays for the current situation of the building might be designed to make the structures, objects and environments more easily understandable.

Information Window

This tool gives information about building elements of structures by using text, image and animation. Windows pop up when an interactive object is clicked.

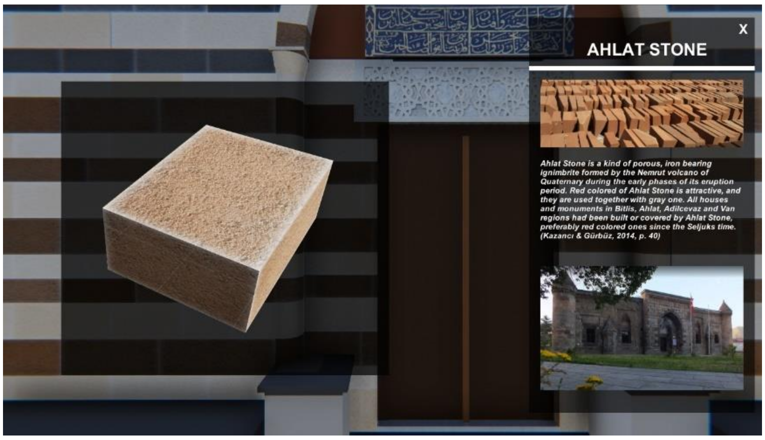

Figure 5.41. Information window for Ahlat stone

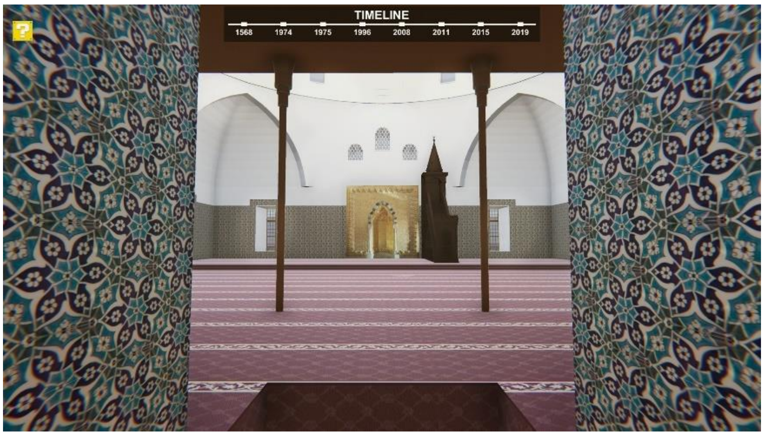

Figure 5.42. Spatial experience for interior

Achievements as Game Elements

In this application because of the time limit, a numbered of achievements were designed for the user, but new ones might be augmented. When the achievement is chosen, a new scene opens which might be named as playground or open-air atelier and user is asked to achieve mentioned goals to complete the task.

5.2.5. Achievement Examples in Hüsrev Paşa Mosque

Pointed Arches

Wide openings and large spaces were started to build with the discovery of arches when people understood that building materials that are not strong enough to cover wide openings might create stronger building systems when juxtaposed, and built primitive arches consisting of interlocked stones. (Kuban, 2002) This system prevents the material on top from falling down by transmitting the load to voussoirs on both sides of the arch then voussoirs transmits that load to springers and imposts. The load transmitted consists of both vertical and lateral loads, therefore springers and imposts are designed to handle resultant of these forces. In time, arches were designed in different shapes as parabolic, elliptic, circular and pointed arches (Kuban, 2002).

In pointed arches, curved sides of archway meet at a sharp point instead of a semi-circular curve, and that type of arch is a notable value of Islamic architecture. In "Pointed Arch Achievement" user is asked to build pointed arches that form portico courtyard of Hüsrev Paşa Mosque with the pieces given in the playground.

Figure 5.43. Pointed arch construction achievement

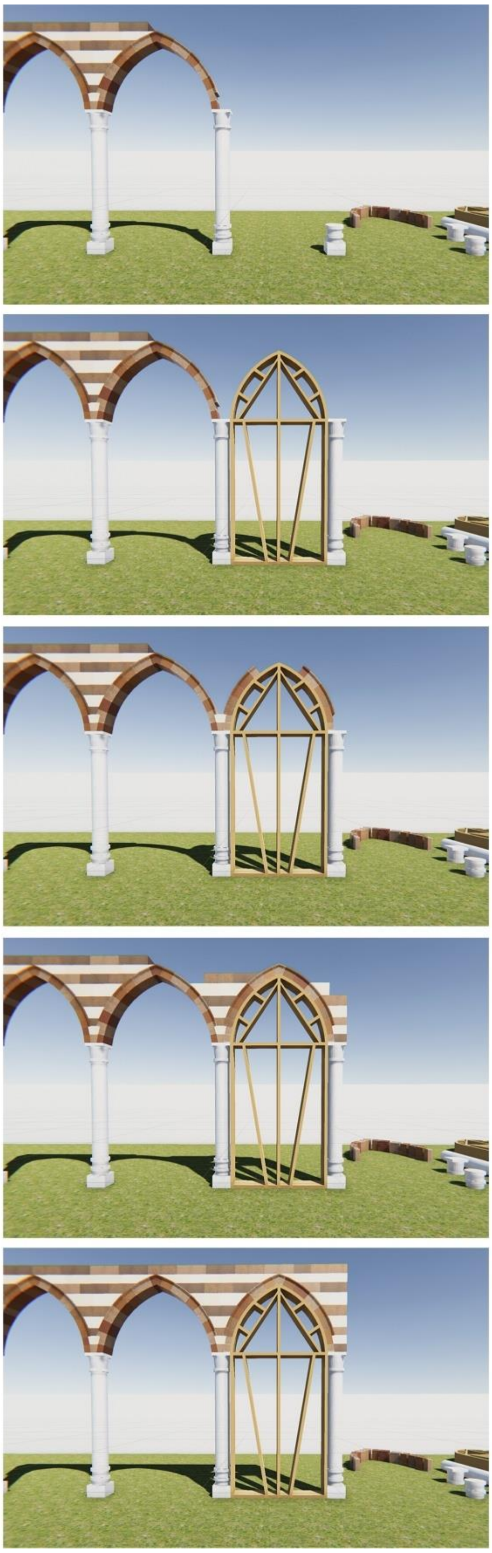

Figure 5.44. Pointed arch construction achievement steps

Cut Stone Walls

As mentioned before, main structural element of Hüsrev Paşa Mosque is rectangular shaped Ahlat Stone which is a local kind of ignimbrite. In the cut stone wall achievement, located in the playground, user experiences stone masonry and builds comprehensive knowledge on that construction technique. User interacts with the ground, arranges the placement of the base and places stones and mortar properly in predefined positions with some margin of error that the software corrects to some extent.

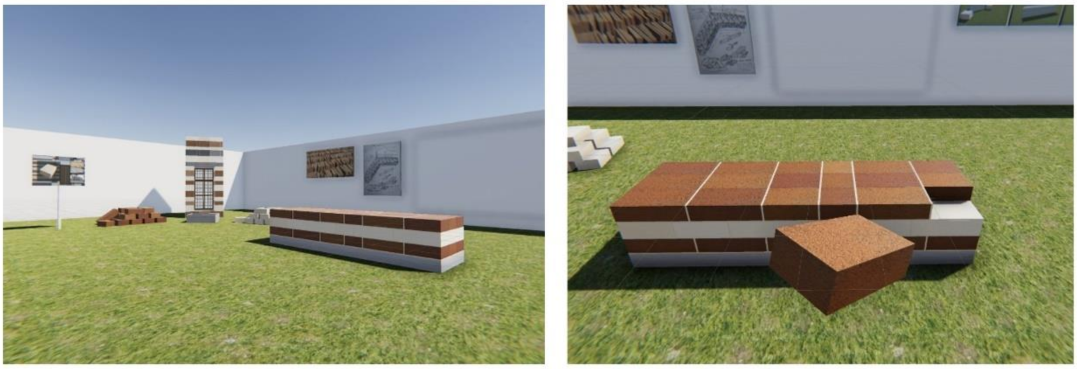

Figure 5.45. Cut stone wall achievement

Exploded Analysis

Exploded analyses in playground enables user to partially examine the structure and analyze interrelations between different pieces that forms the whole. For example, in the sample achievement created in this study, user is asked to examine drum, buttresses, dome, dome coverings and squinches.

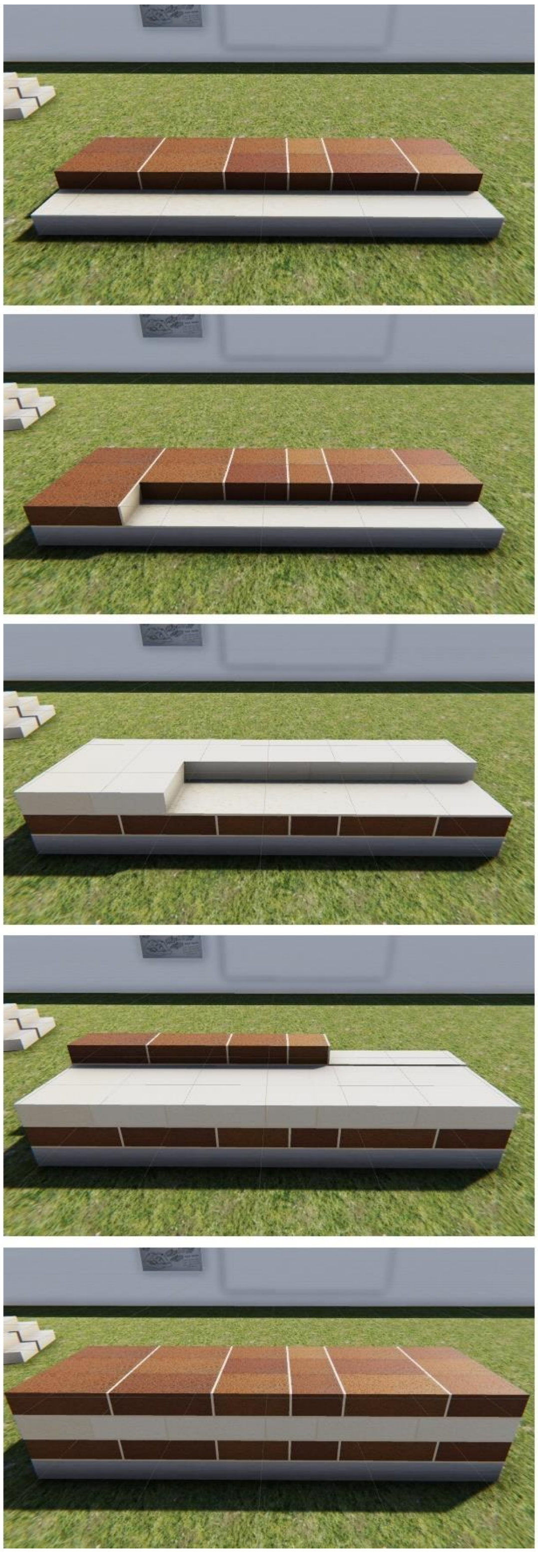

Figure 5.46. Cut stone wall achievement steps

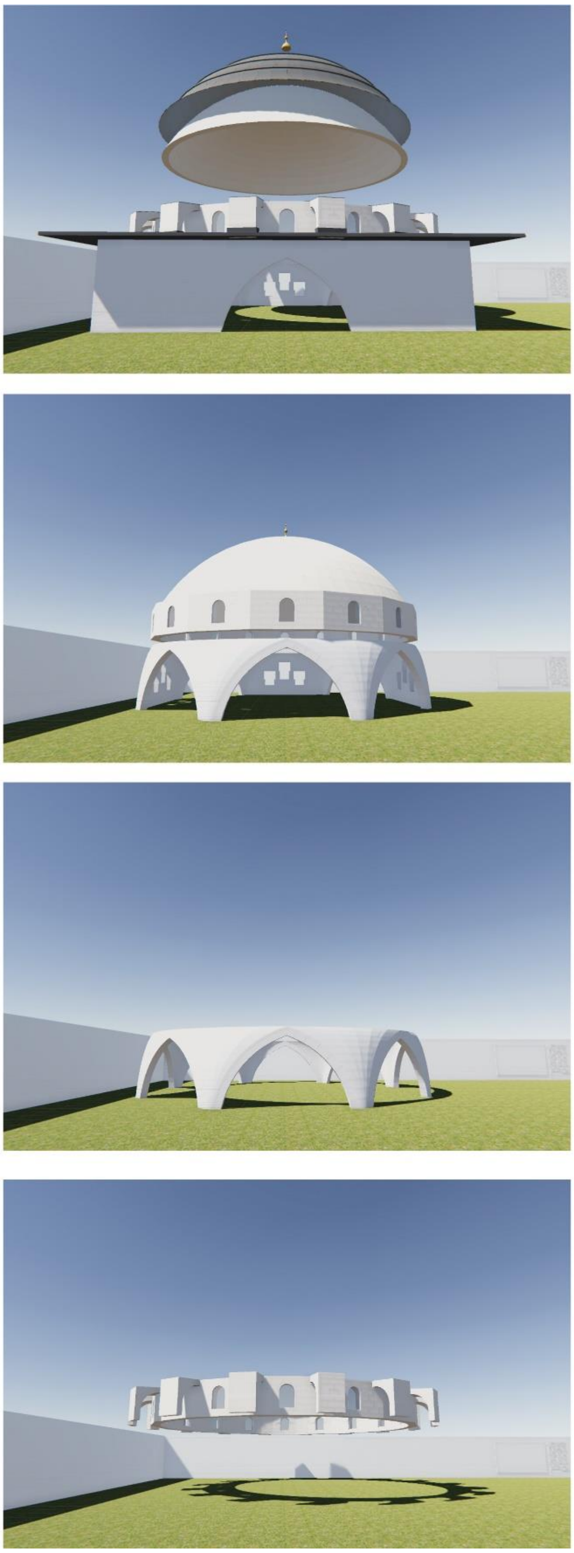

Figure 5.47. Building parts examination

Stone Carving Ornaments

Most common examples of ornamentations throughout history are the ones applied afterwards as murals, wall and floor coverings, mosaics, stained glass and inlays. Each ornament are pieces of different architectural identities and each culture has mastered at least one of them and used frequently in their buildings (Kuban, 2002). Use of different ornamentation techniques are mainly related with the local materials and the cultural aspects as in Anatolian example as Turks preferred stone carving and tile coverings to Byzantine mosaics (Kuban, 2002).

Figure 5.48. Masjid-i Jami Isfahan

Source: URL(66)

In this achievement, user experiences stone carving ornaments that is visible in many parts of the mosque, on top of window frames and in different levels of minaret.

Figure 5.49. Cut stone ornamentation example in Hüsrev Paşa Mosque

CHAPTER 6

CONCLUSION

To conclude, his study has a limited scope since it is a master's thesis, but conceptual framework might be extended or applied in different cases by interdisciplinary teams as aimed as one of the main motivations of the study. Conceptual framework of this study might be used in any architectural heritage reconstruction for experiencers to better feel the spirit of place in an immersive virtual environment with powerful 4D animations using time and motion. Experiencer might analyze and compare the situation of the case structure in different timelines by traveling through them and examining given architectural documents of these timelines. In this way, changes in physical environment might be investigated in a dynamic way as they occurred through time by experiencers, and also the virtual environments and gaming platforms might be developed over time with new findings on architectural heritage. With the increasing use of games in different fields of interest, use of a gaming platform reinforced with animations might cause various people to notice these experiences, as a result, information about pieces of architectural heritage is given on different detail levels correspondingly with the interest of the user/experiencer.

Instead of being aesthetically delightful, 4D model used in the creation of gaming platform should first respect the historical facts and be in accordance with the collected information about the structure or the environment. As every structure might have changes in time as function changes, reconstruction, demolition, material changes, etc. to present this kind of changes to experiencers is important for architectural researches. To make it clear, it should be repeated once again that this comprehensive interaction environment might have bigger challenges and evolve into a more detailed virtual learning environment with future improvements.

The end products of this study is an application for Hüsrev Paşa Mosque as a case structure and a methodology for knowledge sharing applications. Teaching of tectonics in architecture in architectural education will get easier by the help of motion-based animations integrated in these gamified applications. Research and development activities on use of construction material will be encouraged, regionally classified local building materials will be introduced and experiencing them will be encouraged. Potentials and limits of materials can be taught using this method. Today many architects graduate unaware of material properties and this factor causes them to use these materials as it is used in current construction environment which reduces the creativity. On the contrary, many revolutionary architects tried to use materials closer to their full potential and that is what brings development in any field including architecture. For example, in many works of Eladio Dieste or Antoni Gaudi, they did not design in conformity with industrial standards, but laws of physics and hopefully this understanding may be transferred with the use of this virtual platforms. People might learn the tectonic capabilities of materials and experience their uses in case structures analyzed by this method to get rid of the restrains of accustomed limited uses in today's architectural environment.

This new experienced-based presentation and game-based learning method might be better developed to be used in education of architecture. And hopefully use of this method may help increasing creativity of architecture students with positive effects of gaming. In their article 'Video Games and Creative Ability' Green and Kaufman state that;

> While a good deal of research has focused on the association between video games and cognitive skills, recent work has examined the role of video game play in encouraging more positive affect towards creativity and creative thought. (Green & Kaufman, 2015, p. 49)

Use of these new developed tools is not obligatory or these tools are not created as competitors of traditional techniques, but they surely enhance traditional tools and offer much more freedom and accuracy in architectural design. It can be clearly understood that relation of modern tools and traditional methods is mutual. One of the simplest examples might be that, with graphic tablets and digital drawing software, architectural sketches now can be completed in shorter periods of time. As mentioned before this tool might be used as an instructional software in architecture together with other traditional tools.

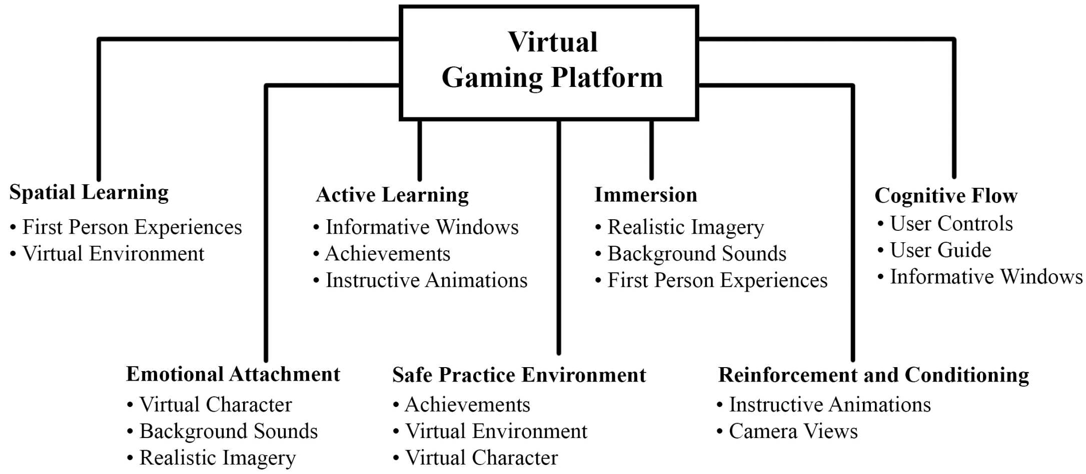

Figure 5.50. Cognitive diagram of virtual gaming platform's features

Moreover, this method may be used in preservation of architectural heritage not only by reviving the use of local materials and construction techniques but also by transferring their data as telling their story. As the outcome of the case structure application, this study may help boosting cultural tourism of the city and play an important role in revival of the old city of Van.

There are two future expectations for the study. First one is forming an online network for architectural heritage. Second one is developing a software or at least an add-on for Unity to use this method to make it easier to create and share information worldwide. Last but not least, the end product and related researches might be reached in author's website: www.mustafaerenbuk.com

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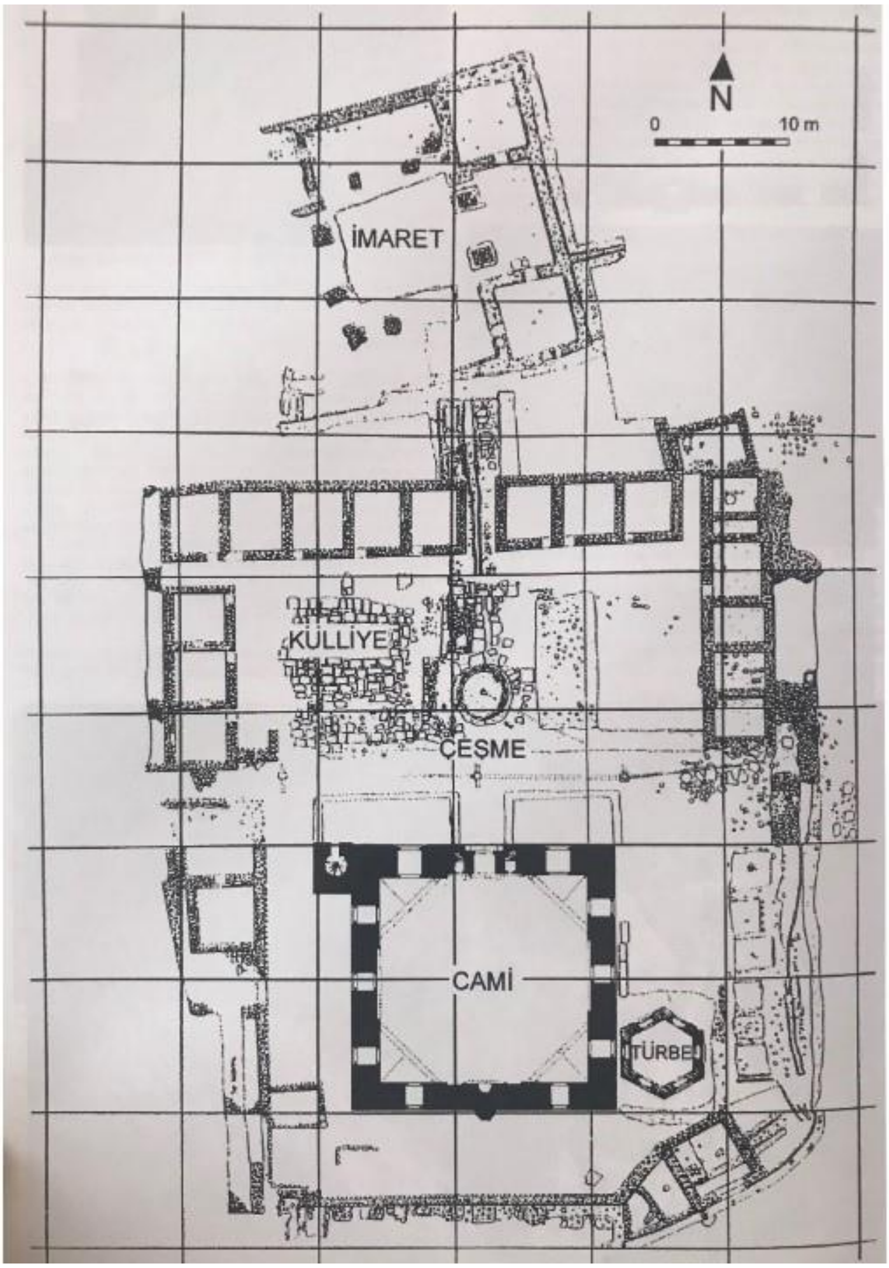
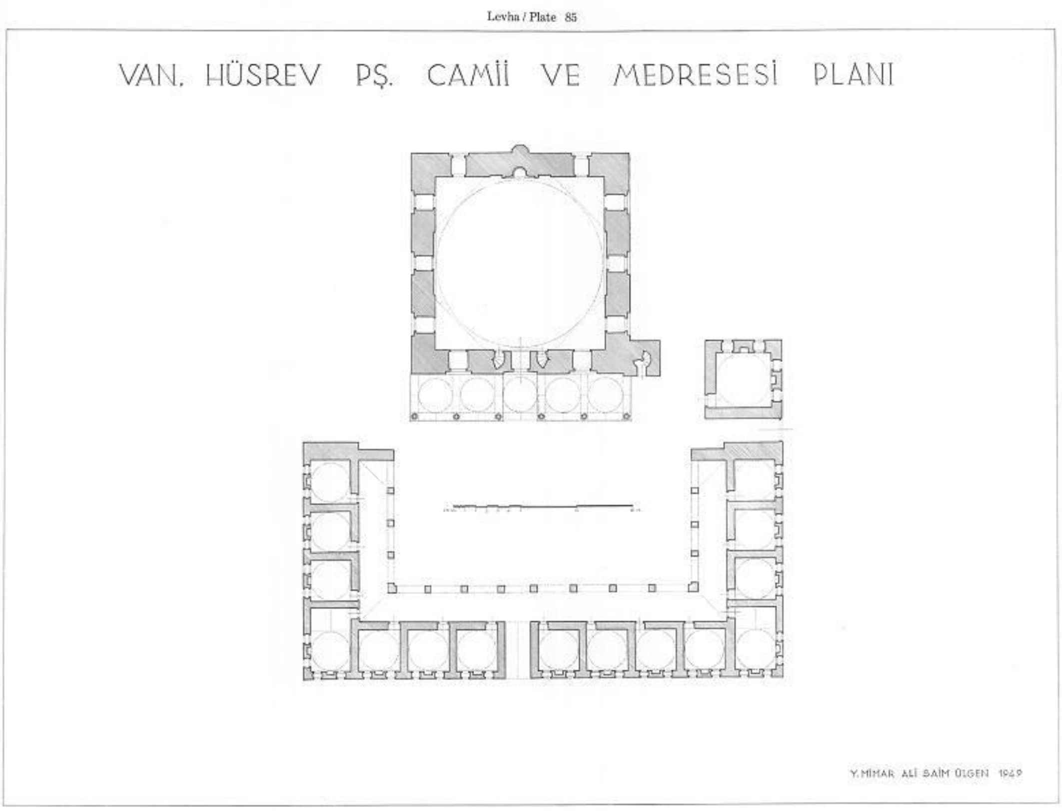
APPENDICES

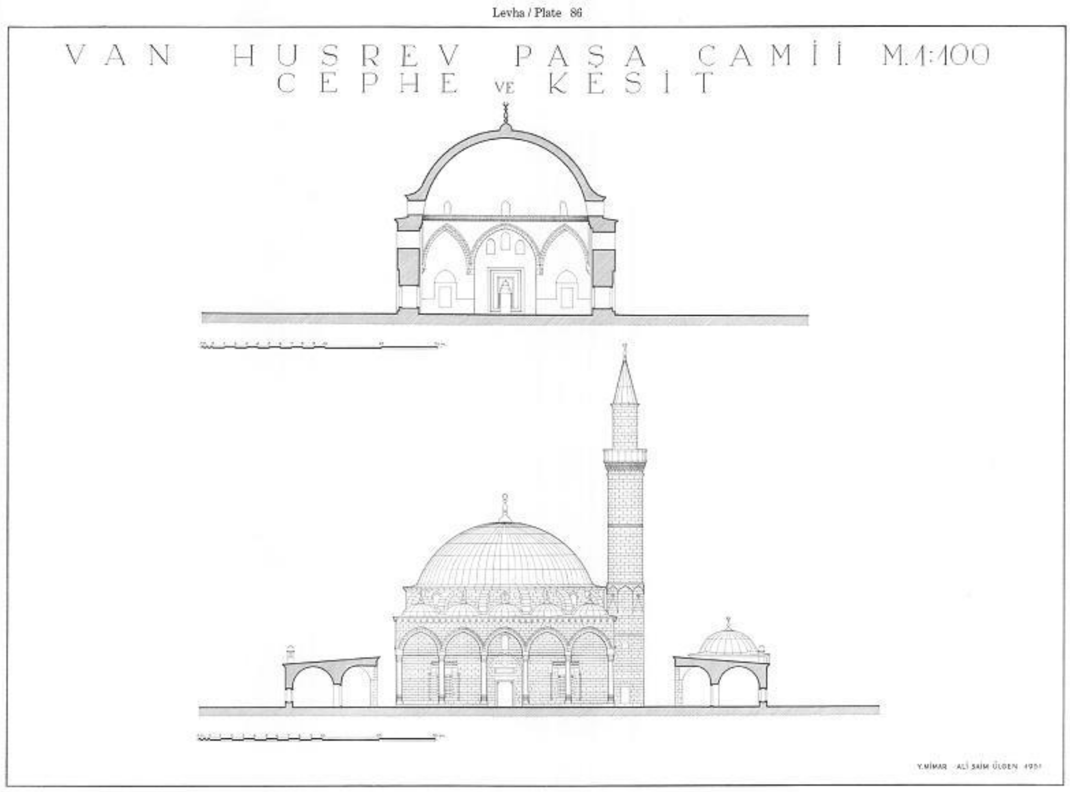
A. Site Plan of Hüsrev Paşa Islamic-Ottoman Complex (Kılıç, 2006)



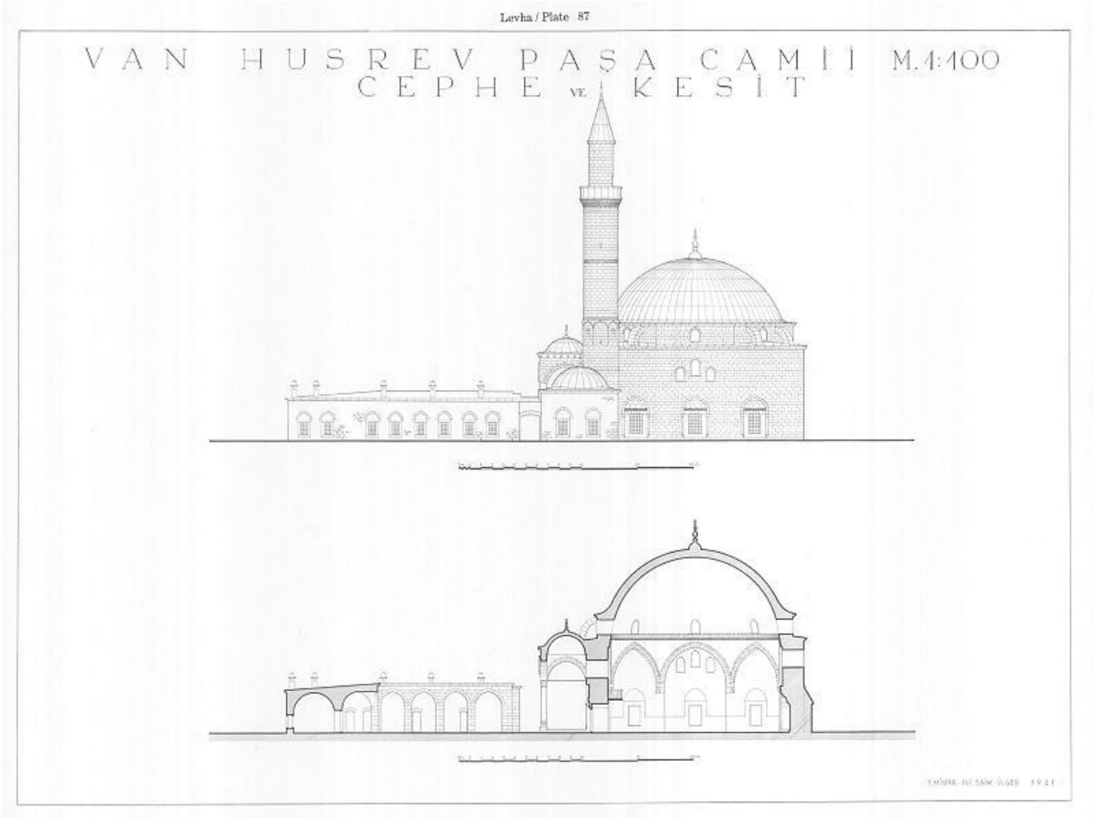
B. Hüsrev Paşa Mosque and Islamic-Ottoman Complex plan by Ali Saim Ülgen



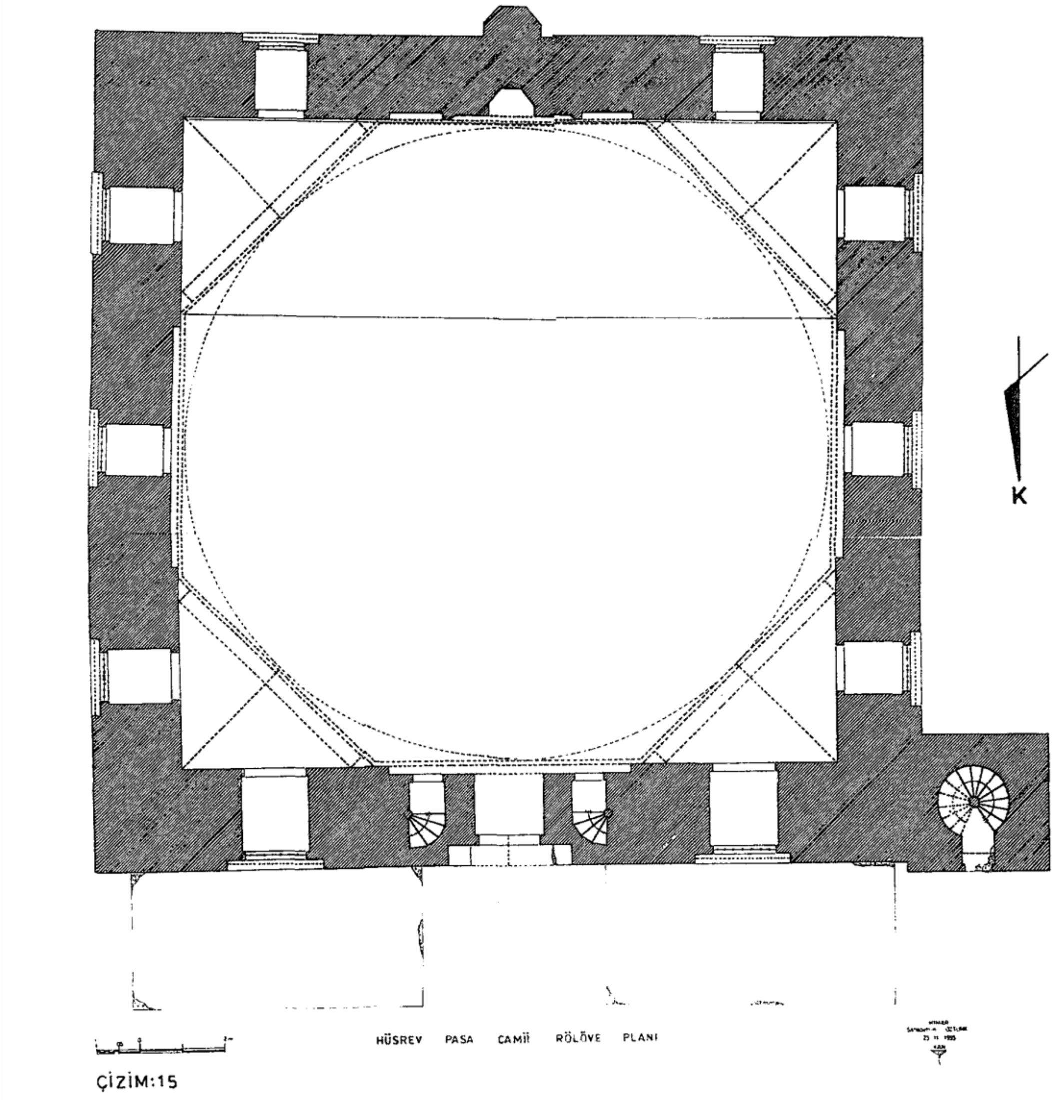
C. Hüsrev Paşa Mosque section and elevation drawings by Ali Saim Ülgen - 1



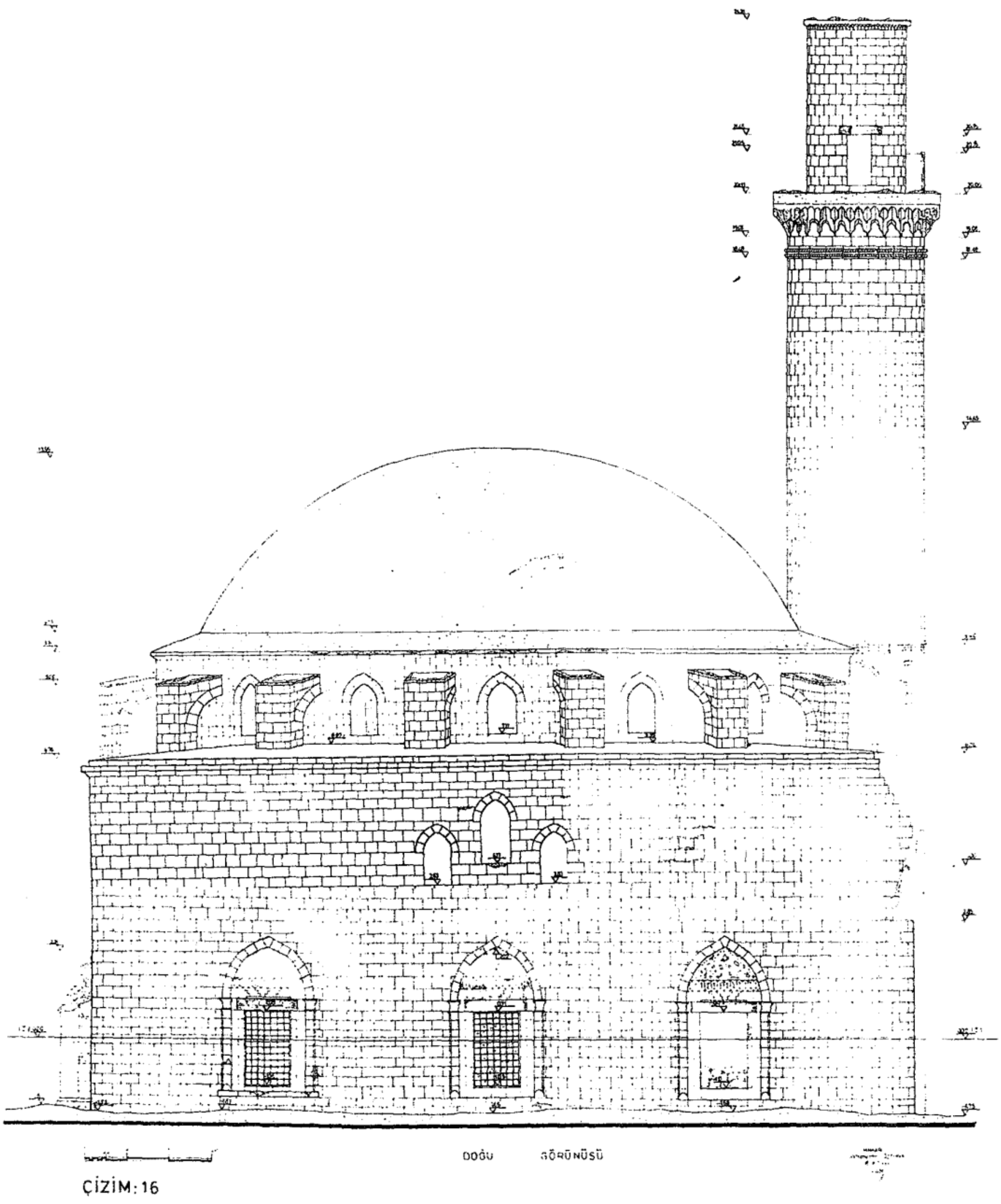
D. Hüsrev Paşa Mosque section and elevation drawings by Ali Saim Ülgen - 2



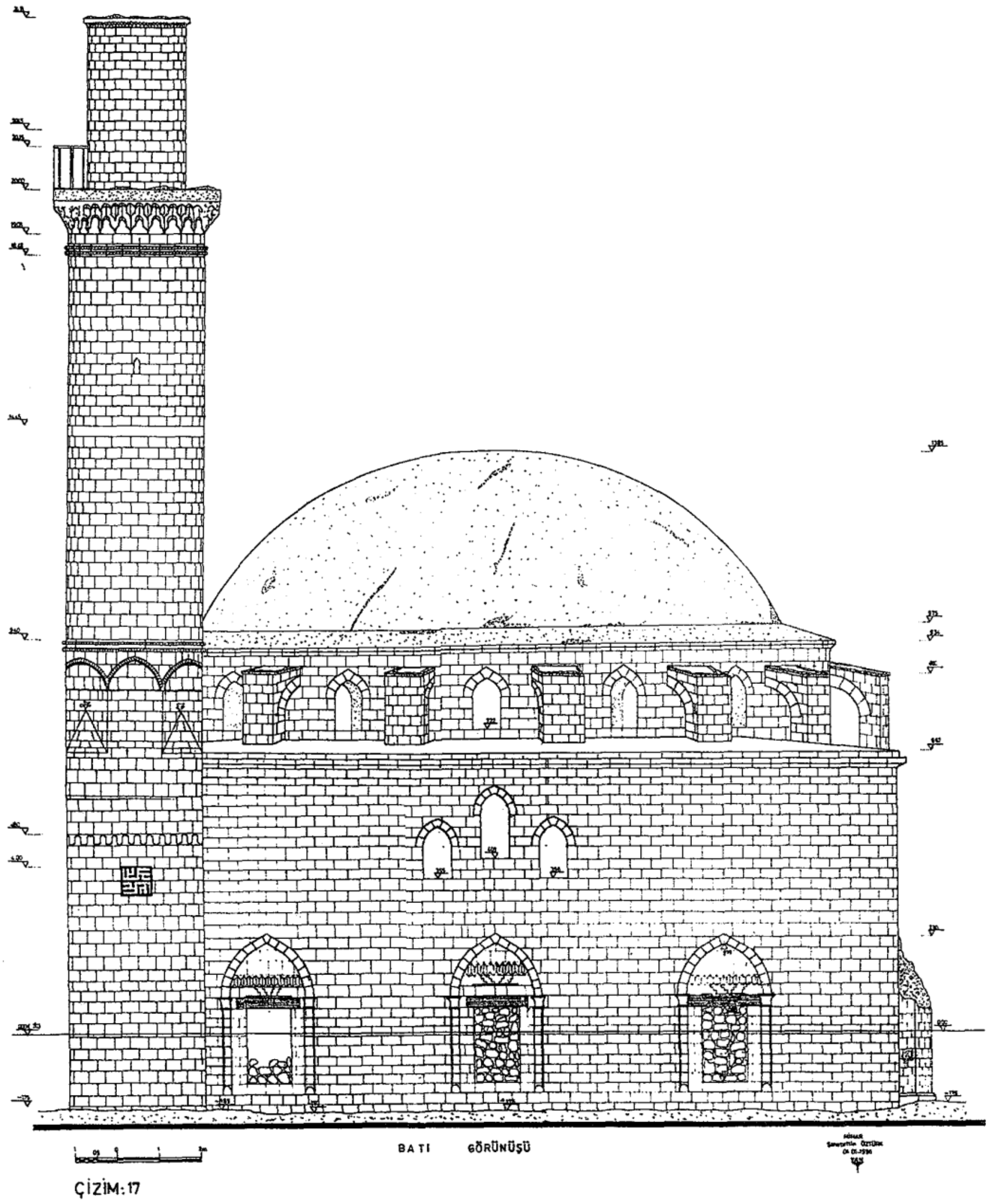
E. Floor Plan of Hüsrev Paşa Mosque in 1996 (Öztürk, 1996)



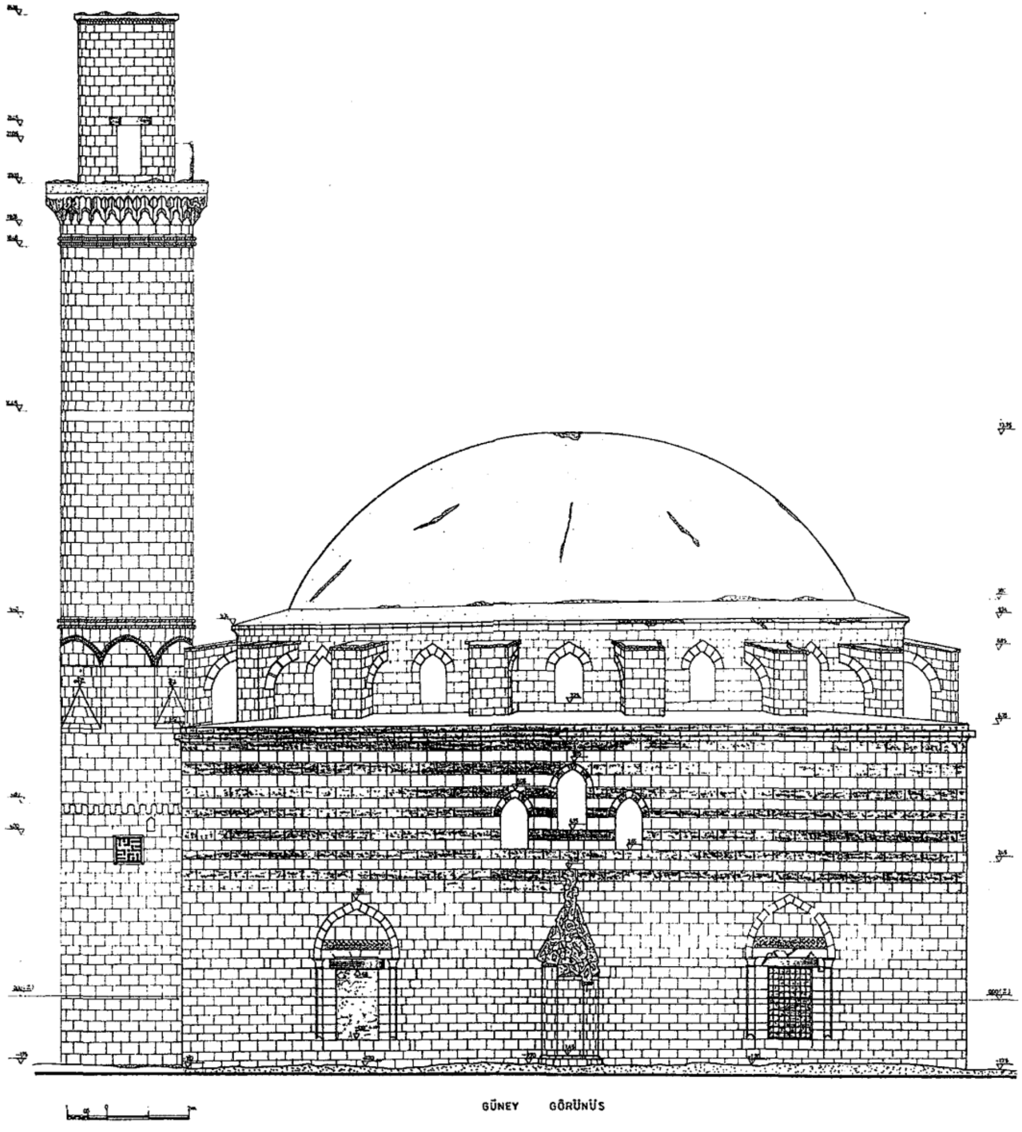
F. East Elevation of Hüsrev Paşa Mosque in 1996 (Öztürk, 1996)



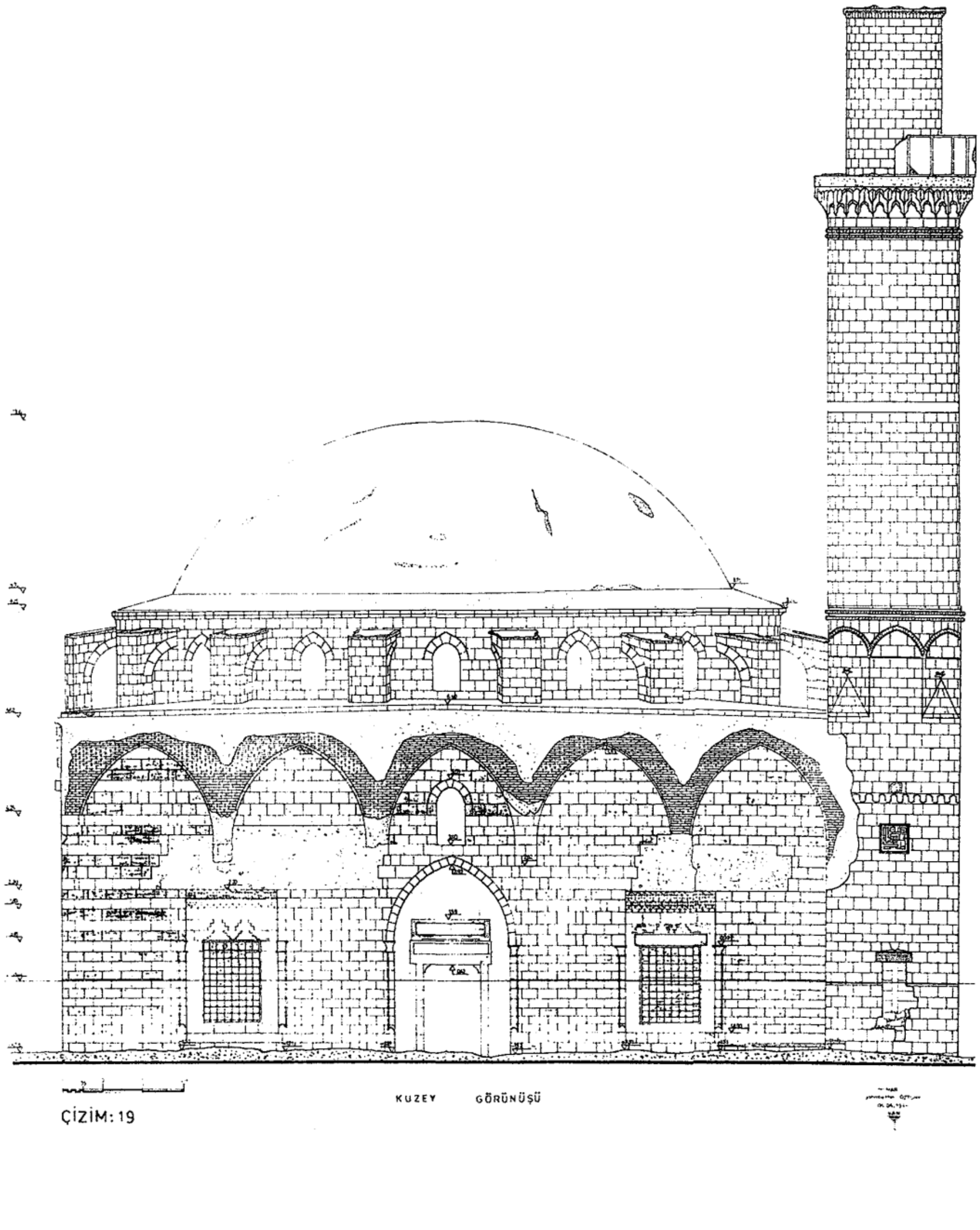
G. West Elevation of Hüsrev Paşa Mosque in 1996 (Öztürk, 1996)



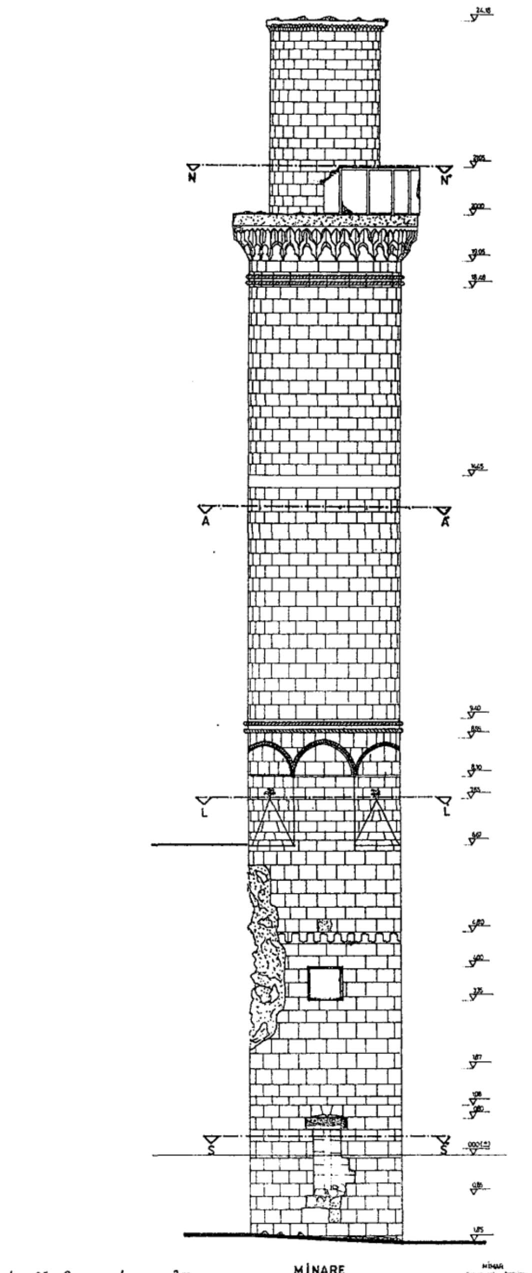
H. South Elevation of Hüsrev Paşa Mosque in 1996 (Öztürk, 1996)



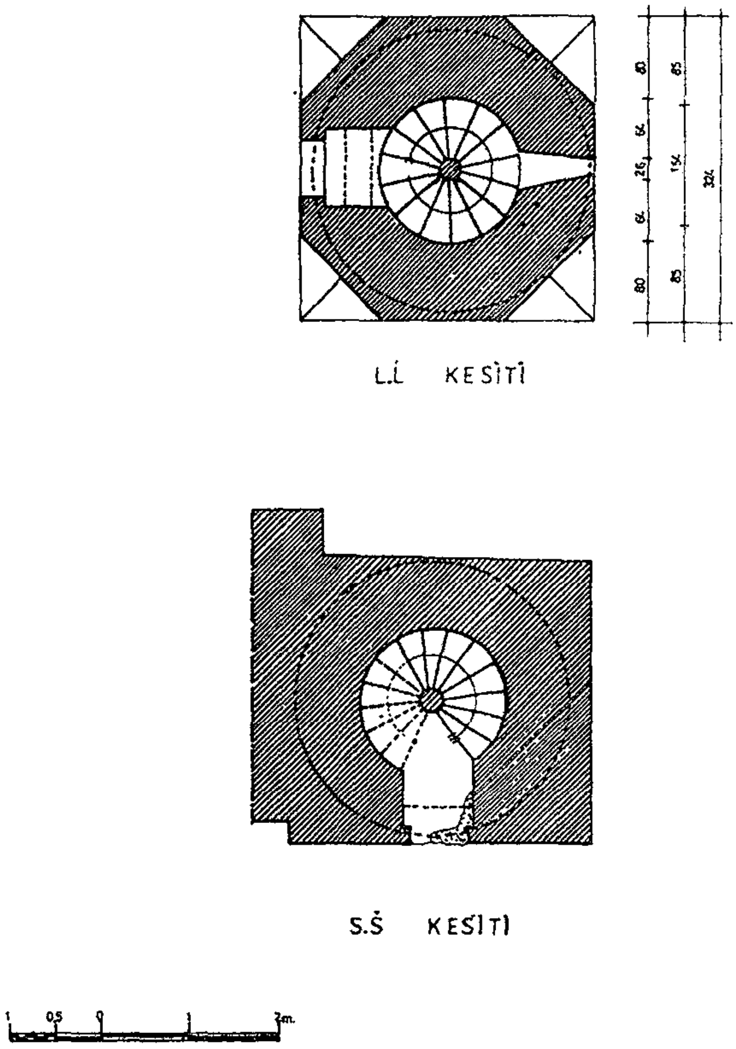
I. North Elevation of Hüsrev Paşa Mosque in 1996 (Öztürk, 1996)



J. Minaret Elevation of Hüsrev Paşa Mosque in 1996 (Öztürk, 1996)



K. Minaret Plan of Hüsrev Paşa Mosque in 1996 (Öztürk, 1996)



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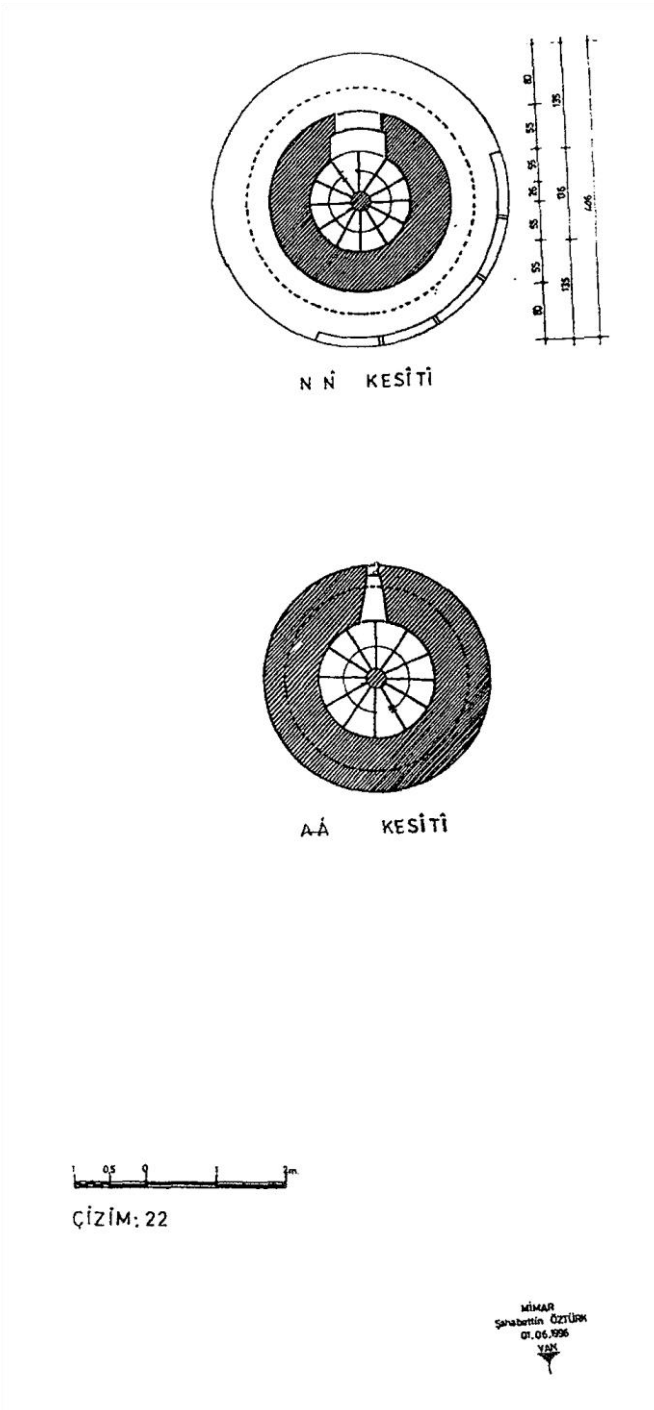
L. Minaret Plan of Hüsrev Paşa Mosque in 1996 (Öztürk, 1996)



M. Top View of Hüsrev Paşa Mosque in 1996 (Öztürk, 1996)