

# VIRTUAL REALITY IN HERITAGE STUDIES AND HISTORICAL RECONSTRUCTION THROUGH ANIMATION – A CASE STUDY OF A 16<sup>TH</sup> CENTURY UNIVERSITY COMPLEX IN THE OTTOMAN WORLD

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*ABSTRACT: The paper describes the research and development of a virtual project based on the visualisation of measured architectural and construction details and extended research into a heritage building i.e. a 16<sup>th</sup> century Islamic complex undertaken as part of an architectural curriculum subject entitled 'Heritage studies'. The modelling was focused on selected portions of the Süleymaniye complex in Istanbul Turkey, while the animation and storyboard integrated findings from a research extension of the project which looked at the link between the social structure of the city with the overall hierarchical nature of the architecture and planning of the complex. Virtual reality and animation tools were used within the process of analysing the architecture and construction technology within the background of the social structure of the Ottoman society during 15th and 16th centuries. The aim was not only to deepen constructional understanding but to discover the historical and social context which lay behind the development of its city life. The virtual reality dimension of the study focused on a virtual walkthrough and animation of the overall Süleymaniye complex and selected parts of the complex such as the madrasa and the 'imaret' or soup kitchen. The focus of the virtual walkthrough is the Süleymaniye Mosque which is surrounded by four medreses, a Darulhadis Medrese which had specialized in teaching Hadith, a medical school, a primary school, a hospital, a reflection hall, a caravanserai, shops, bath house, imaret (soup kitchen), caravanserai (inn), darussifa (hospital) or the hammam covering a 7.3 hectares wide area. Virtual reality was further used to enhance the story board based on the study on the link between the 'waqf' or pious foundations, and development of Ottoman urban life with the ultimate aim of linking these complexes to the social system and structure of urban society.*

## 1. VIRTUAL REALITY IN HERITAGE STUDIES

The paper describes the research and development of a virtual reality visualisation project based on the construction detail and architectural measured drawings carried out during an architectural curriculum subject entitled 'Heritage studies'. The studies, focused on selected portions of the renowned Süleymaniye complex in Istanbul Turkey and further research were undertaken as an extension of the 'Heritage studies' activities. The research analysed the social structure of the Ottoman society during 16th Century and linked it with the physical embodiment of the society at the time i.e. its public architecture. The focus is on the 'imaret' complex which is a charitable building built on pious foundations - that lay behind the development of Ottoman cities. Founded upon 'waqf' or pious foundations, it was found that these complexes became the principal characteristic of Ottoman urban life. These complexes, consisting of schools, mosques, caravanserais, hospitals, libraries, public fountains, can be seen as a reflection of the social structure of the Ottoman society and that architectural form and urban planning to some extent, reflects the social values underlying the society. Based on measured constructional drawings produced after a visit to the site in Istanbul including the detailed construction of the Süleymaniye, the final output and report provides the basis of a 'storyboard' of a walkthrough using VR technology and animation to present the findings.

The project demonstrates how cultural heritage documentation and learning can be enhanced through the use of computerized techniques to visualise information collected and the drawings produced. The development of virtual reality will bring about its increasing relevance in the educational experience as it contributes to cultural heritage education of the younger generation and public understanding and continuous appreciation of universal heritage. Research in virtual reality in architectural education is a relatively young field; however VR can have a

strong motivational impact amongst the students, especially in the appreciation the details of construction and chronological sequence of events in the history of past civilisations.

In this study, VR contributed towards an interactive environment that brings to life the learning of history within the architectural curricula and the historical and social structure context that lay behind the creation of architecture. The focus on studying the prevailing social structure of the Ottoman society brought about an understanding into the social context of architecture as a physical embodiment of the society of its time. The contention is that architecture is a reflection of the social structure/values of a society and that architecture and urban planning to some extent reflect the social and political structure of a society. Through a reconstruction of a complex, the learning process was enhanced as VR was used in facilitating the students understanding of the architectural context and link them to the physical details and urban landscape. It represents a practical aspect of enhancing their understanding of the sense of architectural scale, proportion, and space. To architectural educators, these provide alternatives to traditionally restricted historical curriculum material and allow for more explorations within the learning process.

## 2. SOCIAL SYSTEM AND ARCHITECTURE IN THE 16<sup>TH</sup> CENTURY OTTOMAN WORLD

The story board development aimed at integrating the visualisation of construction and complex elements against the background of its social context. Both the narration and animation highlighted the 'Waqf' foundation which represented the main link between the physical existence of the city and the life of the ordinary people. The *Waqf* - a social, legal and religious institution - played an important role in social, cultural and economic of life from middle of the 8th century until the end of the 19<sup>th</sup>, **is then linked to the physical structure i.e. buildings which arises from this act, and hence represents then a process in which these values become concrete, and from which it has evolved into a form capable of affecting all the aspects of social, cultural and economic life.** These complexes, clustered around the central mosque, are not only places of worship, teaching and learning, and kitchens for the poor but also they also played the role of social catalyst because they led to other gatherings around them. During meal times the teachers and students of a university would meet with other employees of the complex, the poor and travellers. The knowledge obtained and produced was disseminated through these halls.

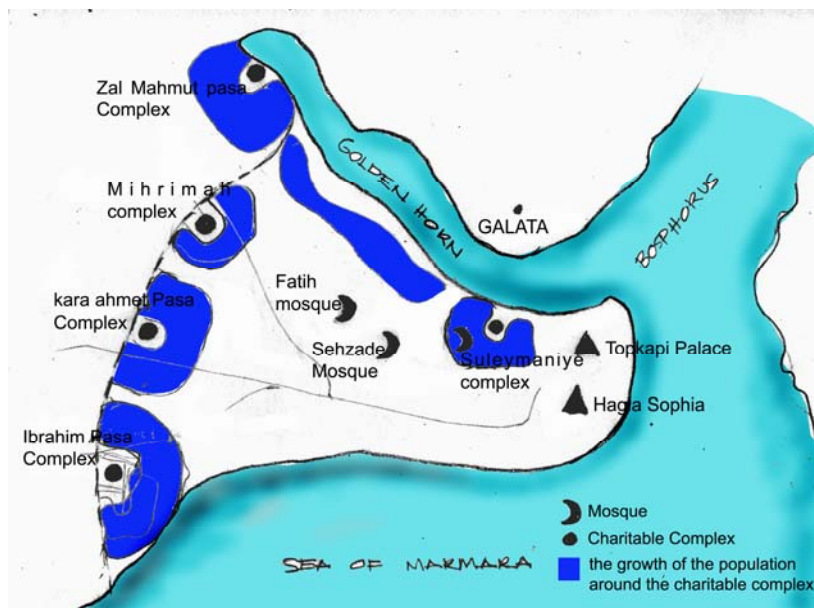


Figure 1: The growth of the population surrounding the charitable complexes of the city of Istanbul

These *imarets* became the nucleus of new cities and towns later established on the main roads in places of strategic importance. The cities, which grew around the public charities, became centres of population and played an important role in the spreading of Ottoman culture civilization (Figure 1). They offered people of all classes a sense of social justice. Through this social assistance system, the potential of the city grew in

proportion of the number of imarets. The scope of the services was particular to Istanbul especially between the 16th and 18th centuries; the Ottoman capital had a social assistance system unmatched anywhere in the world.

### 3. FOCUS OF THE VIRTUAL MODELLING

Based on the measured drawings, 3d Models were constructed focusing on the basic model of Süleymaniye Mosque surrounded by four medreses (Figure 3), focusing on the Madrasa Salis and Rabi. At the same time, a storyboard was developed where the ‘Imaret’ was decided as a focus on the animation. The aim was also show the entire mass of this complex rising gradually with the prominent central dome over a half and corner domes, with its strengthening pillars, to its visible buttresses.

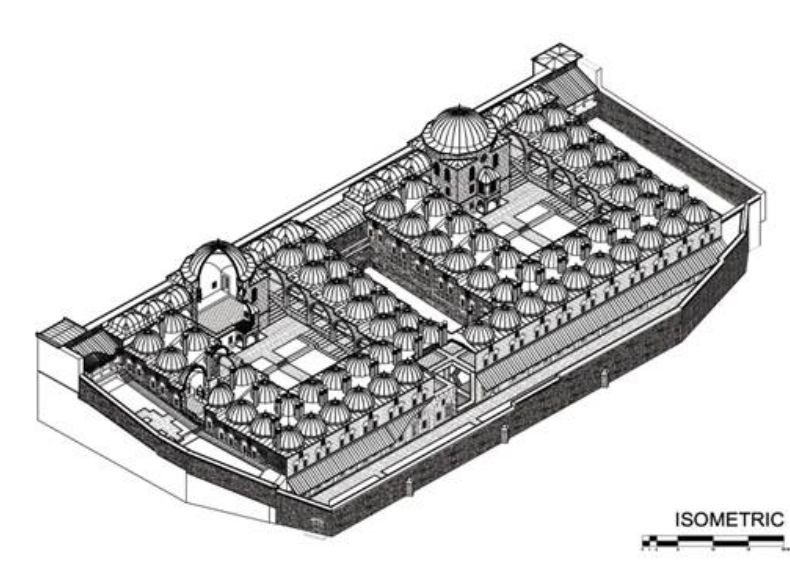


Figure 3: The 3-D model of the Madrasa Salis and Rabi (source: IIUM Heritage Studies)

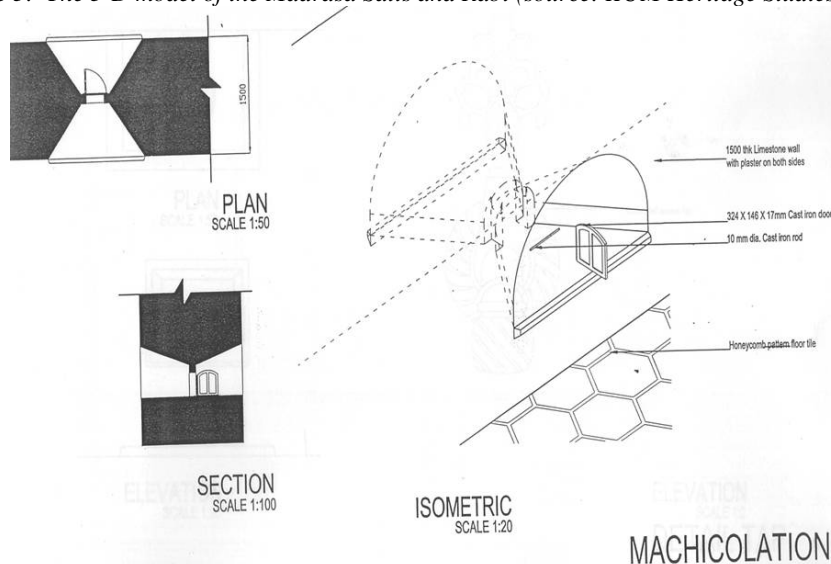


Figure 4: A machicolation designed by Sinan - in main dining hall to serve the food to the poor through a small opening that is punched-out from the kitchen located 1.5 meters from the floor level. The aim was that the people who were serving the food could not see the faces of the poor people and otherwise (source: IIUM Heritage Studies)

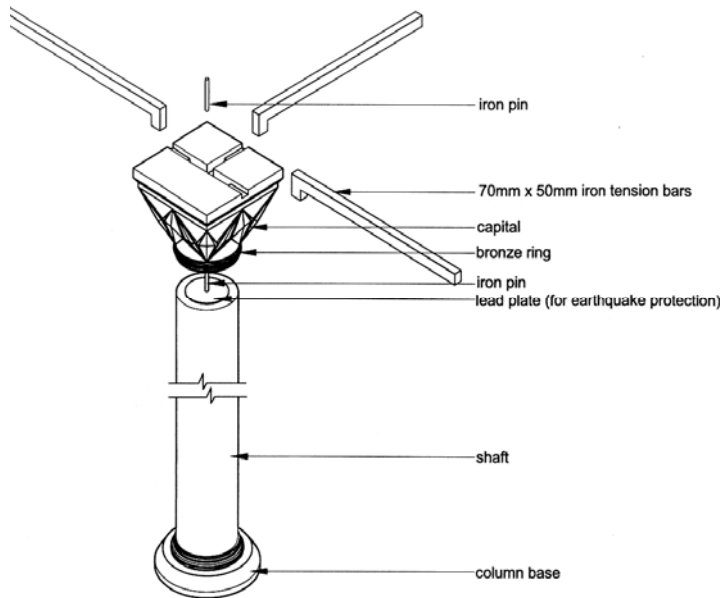


Figure 5: Madrasa Salis, Suleymaniye Complex, and Detail of column  
 ( source: IIUM Heritage Studies)

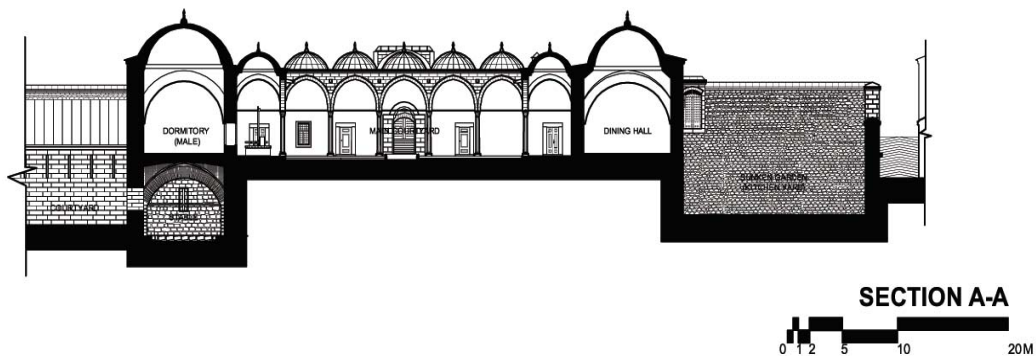


Figure 6: Sectional detail show the interior part and spatial hierarchy of the imaret  
 ( source: IIUM Heritage Studies)

### 3.1 The Imaret Or Soup Kitchen

The focus of the animation was the ‘Imaret’ which refers to a large kitchen that dispenses soup and bread free to the poor, including students, the complexes’ employees and travellers. Animation tools were used to reconstruct selected features linked to the social assistance systems such as a ‘machicolation’ designed by the architect Sinan in the main dining hall. Food was served to the poor through a small opening punched-out from the kitchen located 1.5 meters from the floor level - such that the people who were serving the food could not see the faces of the poor people and otherwise (Figure 4)

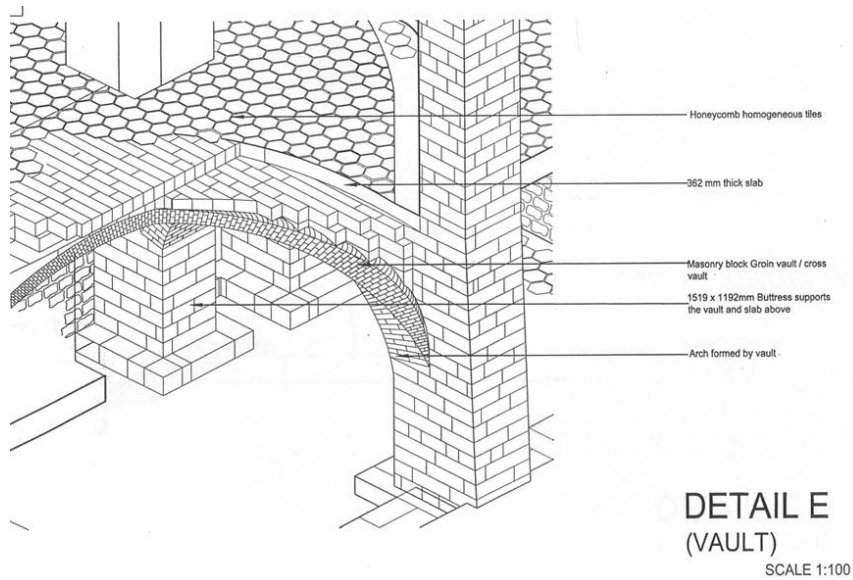


Figure 7. Detail of vaulted construction in the Imaret (source: *IIUM Heritage Studies*)

Based on an detailed drawing of the vault construction in the *Imaret* (as shown is Figure 7), which consisted of mainly brick vault construction i.e. cross vaults barrel vaults and arch barrel vaults with the brick vault structure bridging a relatively large span, a 3D- Model was constructed ( Figure 15).

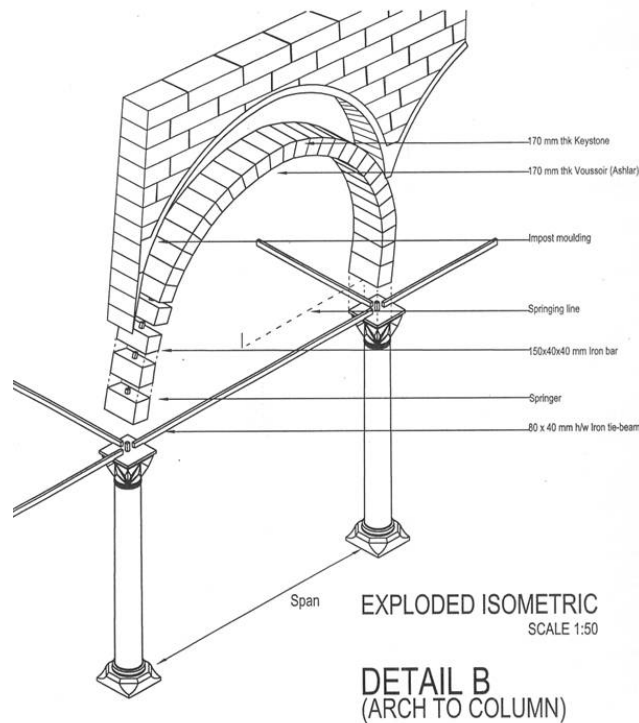


Fig. 8. Imaret. The Suleymaniye – Detail of arch and column (source: *IIUM Heritage Studies*)

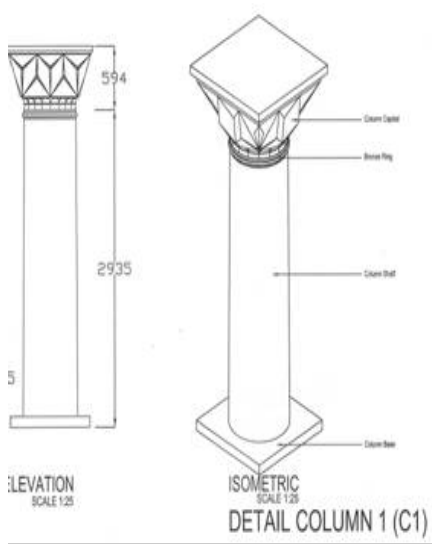


Figure 9: Imaret - Detail of one type of column  
( source: *IIUM Heritage Studies*)

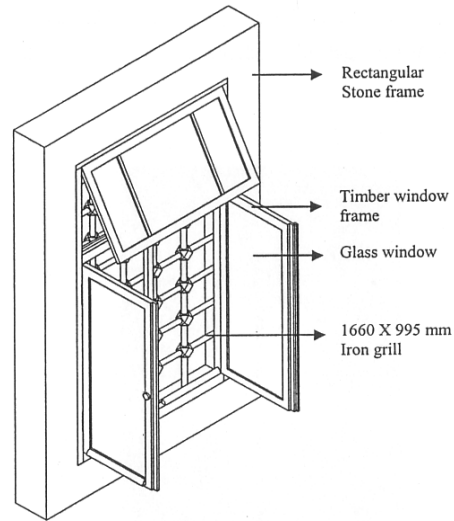


Figure 10 : The typical two panel steel casement window  
( source: *IIUM Heritage Studies*)

There are 20 columns (Figure 8 and 9) that surround the central courtyard supporting the arches in the imaret (Figure 6B). The arch at central courtyard was 4 meters height and 7 meters span. There are two types of window panel found in the Imaret which different in sizes and material, the internal and external panels views. Every window is framed with a rectangular stone window frame that enhances the building façade. The kitchen section of the imaret comprises of the four-domed main space with stacks, supported by a single central pillar and an adjoining domed fifth bay, and it has its own yard and is entered by a staircase. Kitchen and baking facilities are proclaimed by ventilators on top of domes (Figure 11). The kitchen with their four huge ventilators lies behind the refectory along the whole of the west side of the courtyard under the four domes. The dining hall also has two/three panel steel casement windows ( Figure 10) . Figure 12 shows the basic elements of three panels of door elements that found in the imaret building. The panel is horizontally divided with top rail, frieze rail, rail with cast iron rosette and bottom rail.

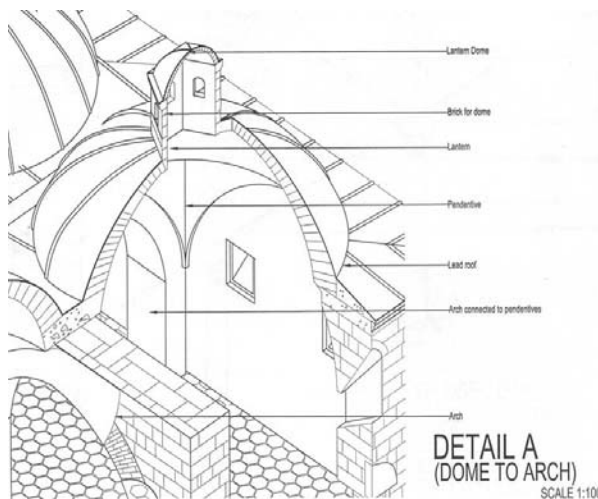


Figure 11: Imaret - The detail construction of dome  
( source: *IIUM Heritage Studies*)

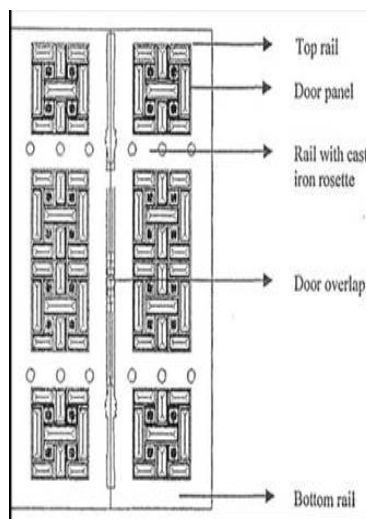


Figure 12; Imaret - The three panel's timber door with geometric pattern carved on the panels.  
( source: *IIUM Heritage Studies*)

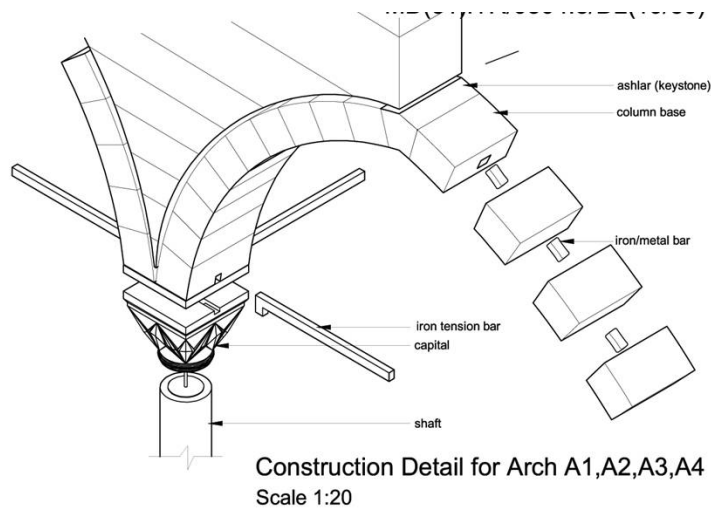


Figure 13 : The Imaret - Construction detail of the arch (source: IIUM Heritage Studies)

#### 4. VIRTUAL MODELLING

The virtual reality construction and animation is focused on visualisation of the measured drawings and linking the animation with the social structure of 15<sup>th</sup> Century and the patterns in planning and architectural form-parts of the Suleymaniye complex. A production schedule was organised in order to organise the work while supervisors and lecturers would oversee the achievement of milestones of the students within the process. (Fig 11). The focus of the animation is on the imaret and medrese, where points on the social system and structure was integrated into the dynamic experience of a virtual reality animation which had further enhanced understanding of the construction technique, architectural detail of a heritage complex and further aid towards an understanding historical context and spatial experience of Islamic architecture in its historical context.

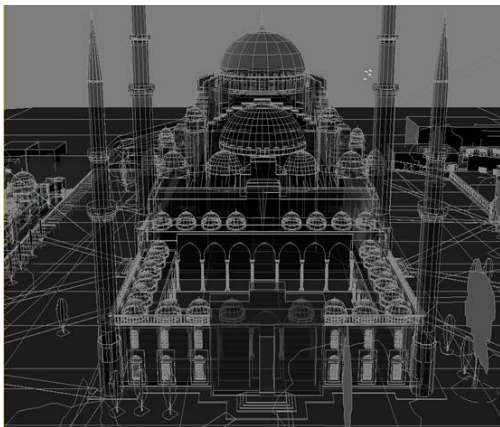


Fig. 15 CAD model of Suleymaniye mosque

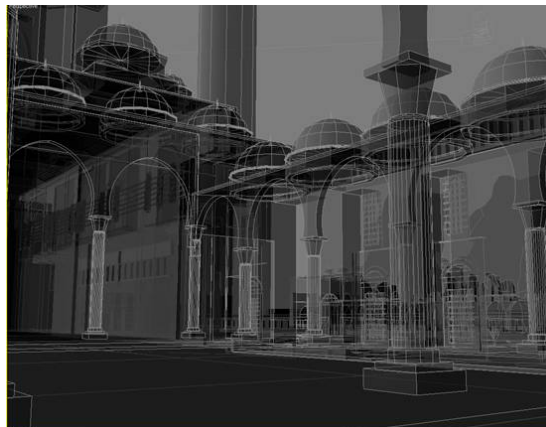


Fig 15. CAD model of detailing based on

		July- August											August- September																		
Description		12	13	14	15	18	19	20	21	22	25	26	27	28	29	1	2	3	4	5	8	9	10	11	12	15	16	17	18	19	22
No	<b>Modelling</b>																														
1	Collection Suleymaniye model data	■																													
2	Model data touch-up or remodelling	■	■	■																											
3	Detailing and construction modeling			■	■	■																									
4	City and alley modeling					■	■	■																							
5	Townscape/landscape modeling					■	■	■																							
6	Texture design and mapping			■	■	■	■	■	■	■																					
<b>Animation</b>																															
6	camera Animation									■	■	■	■	■																	
7	storyboard development & Animation									■	■	■	■	■																	
<b>Lighting</b>																															
8	Exterior Lighting-Istanbul scene											■	■	■	■	■															
9	Interior Mdrasa lecture hall											■	■	■	■	■															
10	Interior Imaret 1											■	■	■	■	■															
11	Interior Imaret 2											■	■	■	■	■															
12	Exterior Lighting-overall											■	■	■	■	■															
<b>Effects</b>																															
13	Special effects with text ( A. Premier)																														
<b>Rendering</b>																															
14	Multi pass rendering																														
<b>Compositing</b>																															
15	Layer compositing																														
16	Effects																														
17	Further compositing																														
<b>Preview Meeting</b>																															
18	first preview																														
20	second preview																														
21	ammendments																														
	Final output																														

Fig. 14. The Suleymaniye complex animation production schedule

Within this process, the learning of traditional material and techniques were exercised as textures were mapped onto the object and model to obtain a realistic look. The process of setting up lighting was undertaken using ray trace and anti-aliasing rendering functions and these assisted in the appreciation of the qualities of light within the vaulted and medieval spaces. Though MAX and VIZ have the capability to apply “sky-light”, the “direct-spot” and “omni” were used throughout the animation. By gathering all necessary data from the research done, an ad-hoc storyboard was conceptualized. These data were integrated into the animation with the use of video editing software, applying the data with a frame-by-frame sequence. The issue is not only to visually represent, in a photorealistic manner, architectural elements and selected monuments but to present these in a meaningful and engaging way, the historical context and social structure which surrounding the making of architecture during its time. At the same time, traditional architectural details and construction is taught through the creative use of state-of-the-art multimedia and technology. The aim is to promote the understanding of the past and to synthetically and comprehensively present the making of architecture, its context and its values.

*Heritage is as much about the living and evolving place people, and environment as it is about static monuments and landscapes*

**Addison, 2000.**

Virtual reality can bring about better comprehension of historical content, including research insights as during the process of creating the storyboard, e.g. students learning from the compositing the animation. Historical understanding was gained from the initial process of juxtaposing an overview world map in the introductory sequence and identifying and selecting from their research, a list of photographs to be used. Technical steps include the use of Adobe Photoshop to adjust the colour and set the file size format into 720x576 formats. Adobe Premier was used to put the visual into the timeline and steps were used to dissolve the visual. The tasks included identifying photograph of the city where this will be dissolved into the 3D scene. Research was done on the ship’s design and building design. Once the camera zoomed inside the city of Istanbul as modelled, the aim was compositing showing the Islamic society structure during 15<sup>th</sup>, 16<sup>th</sup> century. Adobe Photoshop was further used to adjust the colour and set the file size format into 720x576 formats and Adobe Premier to put the visual into the timeline and dissolve the visual.





Figure 16: Final Rendering of Suleymaniye Mosque



Figure 17. Modelling and rendering the entire complex

To focus on the entire Suleymaniye Complex, students worked on the visualisation of the overall exterior view from the top angle – where part of the task was to identify the exterior building structure such as floor plan drawing and building texture image – using 3D Max for the modelling of the whole complex (Figure 16). The social structure was integrated in an animated sequence to show the impact on architecture. As the camera panned and zoomed towards the street level of the complex, the aim was to understand the architecture at human scale and eye level. Based on research studies and the material summarised on 16<sup>th</sup> century, this process includes implementations of the main research findings into the visualisation of the complex where the hierarchy of the building is including the sizes of dome, floor contour and stages, massing, and overall planning. All parts of the building were studied including texture image and floor plan where 3d modelling was used in the process of extracting and animating the specific model parts (Figure 17).

Adobe After Effects was then used to highlight the parts of the model where tasks including identifying main details, texture and image. As the focus changed towards the Madrasa, the visualization was focused on the lecture hall where the aim was to show details of the interior learning hall. Where the animation ends, the focus was on an overall walkthrough of the Sulymaniye complex, panning to the sky where 3Ds Max was further used towards animating the camera and lighting effects.

## 5. STUDENT FEEDBACK

A questionnaire-based survey was conducted after the VR project to represent a simple feedback mechanism to gauge the students' opinion based on the outcome of this project which combines learning of heritage with Virtual Reality (VR) technologies. The questions were given based on the aim of the virtual reconstructions of cultural heritage complex – which was to lift up the traditional way of teaching history and heritage. Hence students were asked basic questions on whether the Multimedia and modelling tools combined with historical and architectural data offered an opportunity them to improve their skills while at the same time, to deepen their understanding of historical events, civilisations and heritage construction techniques. About 30 students, mostly from 4th year architecture, participated in the survey, which included questions on their skills before and after the project, their opinions on the understanding the subject matter such as construction, history and civilisation after the completion of the project. The following are basic results – the term 'unknown' refers to 'no answer given'.

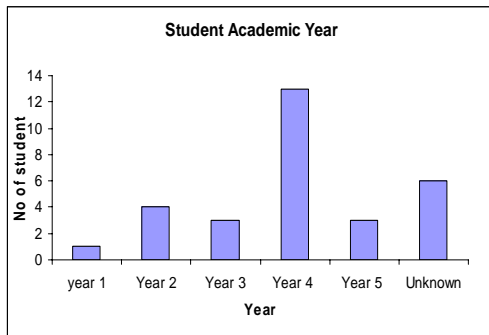


Fig. 18. Students academic year involved

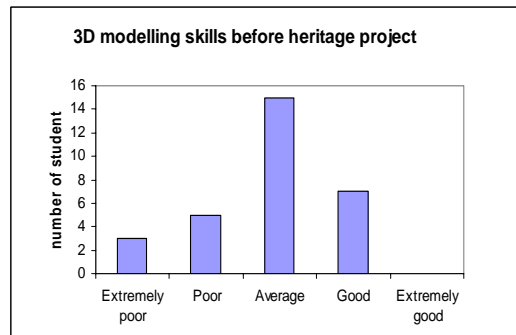


Fig. 19 Students' perception of their modelling skills

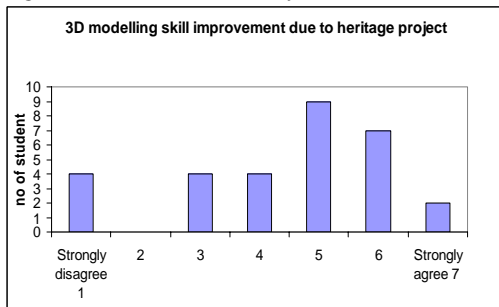


Fig. 20. Students opinion on improvements in skills ( 3d modelling and animation)

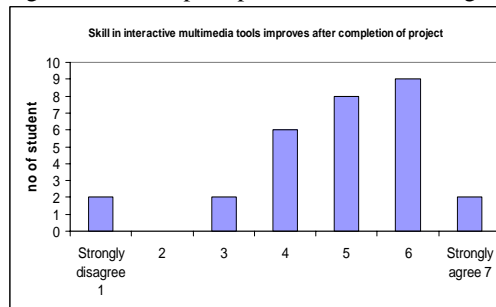


Fig. 21. Students' opinion on improvements in multimedia skills

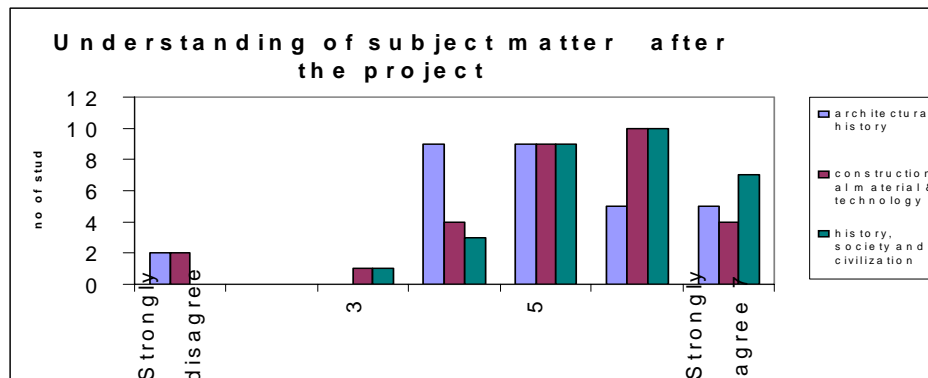


Fig. 22. Students' assessment on their level of improvement of the understanding of history and constructional technology of heritage buildings after the project

As seen from Fig. 18, most of the students were from 4<sup>th</sup> year architecture – with the opinion that their 3d modelling skills being of ‘average level’ before the project. It can be seen that the VR heritage project enabled them to improve their skills, particularly in their opinion - in multimedia presentation and composing - which improved due to the project. The level of improvement were assessed as higher than 3d modelling skills (as in Figure 20), possibly due to the students have already learnt various aspects of 3d modelling in their earlier years of study. Hence the heritage project provided a jump start in their multimedia skills learning (Figure 21). Fig.22 summarises their opinions on whether the VR heritage project presented an opportunity to deepen or increase understanding of the subject matter – i.e. whether they improved their knowledge and understanding of history and construction. The students’ response was extremely positive, with a handful disagreeing on this statement. The overall results demonstrate evidence of their agreement that their understanding of heritage construction and history and civilisation significantly improved, while knowledge of ‘architectural history’ was slightly less in significance. This could be due to the architectural history subject encompassing a wide range of countries and eras, while this project focused on specific time and place. Fig. 22 gives an overview of the students opinions on the benefits of the programme and an outline of the achievements in terms of both skills development and subject matter education.

## 6. CONCLUSIONS

Virtual reality represents a high-end technology that has an exciting and explorative quality to complement more traditional methods of architectural learning. Increasingly it is developing into a necessary component in the educator’s arsenal of tools to educate and afford opportunities to learn and even experience historical environments, which for reasons of time and distance cannot be experienced or learnt in an engaging and meaningful way. In this project, virtual reality tools are used to enhance a story board based on a study of the linkages between the ‘*waqf*’ or pious foundations - which was the principal characteristic of Ottoman urban life. The modelling was based on detailed construction plans of the *Suleymaniye*, which demonstrated the achievements of construction techniques during its time. The tasks involved the transformation of 3D models retrieved from the measured drawings database collection with research output to form a focused extension of the project entitled ‘*A study of social structure and its link to public architecture – The Madrasa and Imaret of the Suleymaniye*’, which assisted the Overall VR and scene Construction. The 3D CAD models were produced from data gathered during a heritage visit to acquire existing site and construction measurements which formed the basis for the virtual reconstruction of the complex, which was integrated with research on its historical context. Not only did this project enhanced the student capacity for learning constructional knowledge and detailing but it gives a motivational value, particularly in the learning of history and historical artefacts through the re-construction of heritage building and construction techniques. It represents an example of how VR technology can help quantitatively and qualitatively expand, deepen and enhance the architectural educational experience through its functions as an instrument of historic learning, research, animation, and reconstruction of past architectural and urban planning legacies.

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