Developing 3D graphics software as educational material for museum education course (The case of hunat social complex)

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Abstract

This study aims to develop a 3D graphics software that will be used during the visit of historic places in museum education course and applying this application to an example historic building. The software is a virtual reality application that will provide the opportunity to visit historic places in a three-dimensional and interactive virtual environment in terms of spatial relations, historical data, structural and material characteristics of these places. The software can be accessed by mobile devices such as tables and smart phones via the Internet.

Museum Education course is a practical course in which various activities and workshops are carried out while visiting museums and historic places in addition to the discussion of basic issues such as the history of museums, types of museums, and their functions. In this course, given the sketches and the educational materials containing visual-textual information on the historic buildings, students visit these buildings and create their own experiences through the guidance of these documents. In this regard, "What could be a new and different teaching material that will enrich students' experiences?" appears to be an important question. This question has led to the idea of developing the software that will allow new experiences during the visit of historic places, and this idea bases the research problem of the current study.

Accordingly, the virtual-reality application needed was developed by the researchers within the research project funded by Erciyes University. The software allows entering the building (walkthrough), getting a bird's eye view around the building (orbit), and obtaining visual-textual information through selecting the details in the building (inscription, muqarnas, ornamentation, etc.). The software has been developed as the multi-platform with open source codes using Action Script 3 programming language, Air SDK and Away3D SDK in the development environment of Flashdevelop supported by OpenGL ES2.0. The Religious school (madrasah), Mosque, and Mausoleum buildings in Kayseri Hunad Hatun Social Complex were selected as the example buildings in the pilot

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application. The three-dimensional digital models of these buildings have been created in the computer environment to reflect the architectural features using low polygon modeling method within the aforementioned project.

The software developed for the museum education courses has provided students with the opportunity to examine the historic places more closely through the virtual-reality application that can be accessed by tablets and smart phones via Internet while they physically visit these places. This software can be considered rich material presented to the use of people interested.

Keywords: Museum Education, Hunat Hatun Social Complex, WEB Based Virtual Reality, 3D Graphic Software

1. Introduction

This study aims at developing graphics software that will be used by tablets and smart phones during the visit of historic places in museum education course and applying this application to an example historic building.

The scope of research includes analyzing the needs such as course needs, the abilities of the software that will meet these needs, the platform on which this software will be developed, planning, and applying the development stages for the graphics software to be developed for use during the visits to historic buildings, one of the practices of museum education course.

Museum education course is a required course offered in the third year curricula of the departments of Painting, Sculpture, Ceramics and Glass Design, and Visual Communication Design at Erciyes University. Museum Education course is a practical course in which various activities and workshops are carried out through visiting museums and historic places in addition to the discussion of basic issues such as the history of museums, types of museums, and their functions. This course includes practices in which students prepare reports by creating their own experiences through a series of activities such as doing detailed examinations in the place, taking photos, drawing sketches, and gathering information. In this course, given the sketches and the educational materials containing visual-textual information on the historic buildings, student visit these buildings and create their own experiences through the guidance of these documents. This situation reveals the importance of the documents and materials used to have students gain desired knowledge and experience. Using various and interesting materials prove to be more effective. In this regard, "What could be a new and different teaching material that will enrich students' experiences?" appears to be an important question. This question has led to the idea of developing the software that will allow using a new educational materials and offering new experiences to the students during the visit of historic places, and this idea bases the research problem of the current study.

While creating the syllabus of the museum education course, the rich history and museums in Kayseri are discussed in detail, and the practices of this course are carried out in these places. It is seen that in this section of this course, the students pay much attention to the unique examples of Seljuk architecture, and Hunat Hatun Complex is, particularly, at the center of interest. This invaluable work is composed of a mosque, madrasa, and Hunat Hatun Mausoleum. The complex is a unique building that has rich details, with the spatial relationships with each other, structural elements, portal doors, inscriptions, and decorations. Hunat Hatun Complex has been selected as the example building in the educational software due to its aforementioned characteristics.

2. Determining Software Features

2.1. Determining the Course Activity Needs

The selection of appropriate educational technology is a matter of great importance in order to create an effective learning and teaching environment. Some rules are to be taken into consideration

while selecting the technology. The issues discussed, goals, and behaviors should be considered and fit students' needs. Moreover, they should be easily accessible (İsman 2003:44). It is necessary that the new material created for use in the Museum Education course have all these features. In order to determine software features, the following needs based on the activities are identified by the field expert of Museum Education Course. This educational material is expected to help the students to focus on understanding the architectural plan, structure features, and other details of the building appropriately and to be equipped with visual/textual elements and mechanisms such as the feeling of immersion into the building. To this end, the software needs were determined and developed in this direction.

2.2. The Necessary Features of the Software Based on the Needs of Course Activity

A two-stage approach was followed in determining the needs of course practices: determining the current practices and activities in this course as the first one, and what innovations and improvements can be added to the current activities by the new digital educational material as the second. Expert views were obtained regarding these pre-determined needs.

In the course activities, the students are provided with various documents that introduce the building and that are expected to follow the details of the building on these documents. These documents include short textual information about the historical and architectural characteristics, the sketch, and the images of the decorations and inscriptions of the building. The structural elements and the location of the ornamentations are left to the students' observation. Students can match the objects that they see on the buildings with the ones on the documents and read the related explanations. In the beginning of the study, it was intended to enrich the contents of the documents with the capabilities of digital media and include them in the software.

Moreover, in addition to using the information available in the documents in the software to be developed, the following features were aimed to be included in the software.

While visiting the place non-physically, providing
- The opportunity to walk in the building through First Person View,
- Enabling students to have perspectives that are not possible in the physical visit,
  - The opportunity to have a dominant scale of look (bird's-eye view) at the structure and the general settlement plan of the building,
  - The opportunity to move around (orbit) the building at three axes,
  - The opportunity to approach and examine the distant objects (which are higher than their eye-level) during the physical visit
- The opportunity to practically obtain explanations and images by double-clicking on the objects such as structural elements, decorations, and inscriptions.
- The opportunity to read the Turkish translations by double-clicking on the inscriptions,
- The opportunity to access information windows by double-clicking on the object in the walking and orbit mode as well,
- The opportunity to switch between bird's-eye view (orbit) and walking (walkthrough) modes with just one click

are believed to enrich the course activities. Furthermore, considering that the software should be equipped with the mechanisms that a student, as a first-time user, can easily understand and with the windows that will provide practical tips on the use of software, it was developed in this direction.

2.2. Platform and Software Development Environment

Because the software is to be developed as an application that students will individually use during the visits to the historic building, it should be accessible through the equipment that students currently have during the course practice. This limitation was taken into consideration while selecting the platform on which the software was to be developed and run. Thus, it was decided that it could be installed and run on common smart phones and tablets. In addition to this, the software will also run on desktop web browsers for in-class and extracurricular activities.

When the software is developed to run off line, it will take additional preparation to be installed on mobile devices before the course. Since the class time allocated to practice was limited, it was thought that it would affect the course adversely and decided that the software would be accessed online. As to installing the plugins required for the software to run, since the common applications and websites such as Facebook and YouTube are constantly updated, it was decided on Flash AIR SDK.

3. Creating the Three-Dimensional Digital Models of Hunat Complex and Texturing

3.1. Creating the Three-Dimensional Digital Model

Polygonal Modeling method was used to create the three-dimensional digital model of the buildings. Polygonal Modeling method can be likened to creating statues using polygons in the virtual space. A polygon is a three dimensional structure formed by three or more points called vertices which are combined through sidelines known as edge (Franson D., Thomas E., 2007:8). Vertex, on the other hand, can be defined as a point that has location in three dimensional space (x,y,z) but no width, length, or height (Gahan A., 2011:6). The two-dimensional orthographic architectural CAD drawings of different views, such as plan, crossection, and view were used as reference in order to create 3D geometries at the right proportion and size. This method is also known as Blueprint method (Franson D., Thomas E., 2007:23). Some of the two-dimensional CAD drawings were made using the drawings available on the Report of Hunat Hatun Restoration dated 06.11.2007 with the permission of Turkish Republic Regional Directorate of Foundations, and the other drawings were created with AutoCAD on the building after measuring the horizontal and vertical dimensions through optical measuring device. Two-dimensional drawings were re-scaled by overlaying them in the three-dimensional space of 3D Studio MAX and changed into the right scale compatible each other. Thus, a reference overlay was created for modeling. The reference overlay drawings of Hunat Madrasa (a) and Mosque (b) buildings are given in Figure 1.
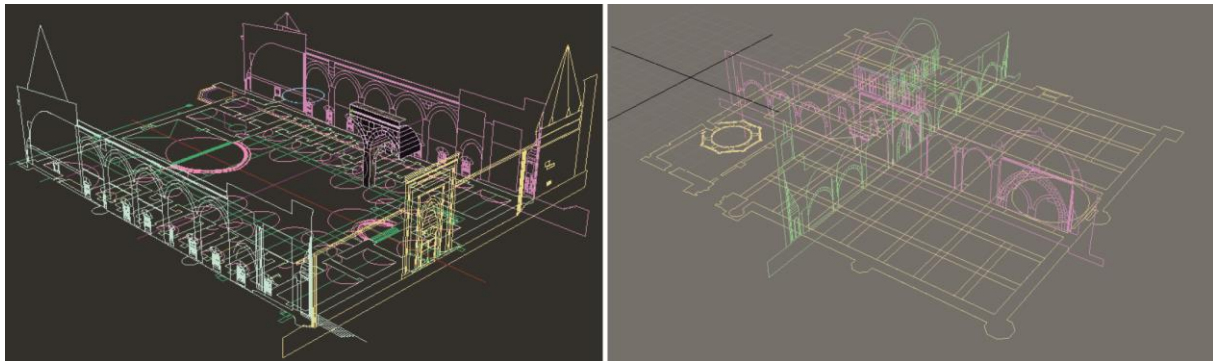
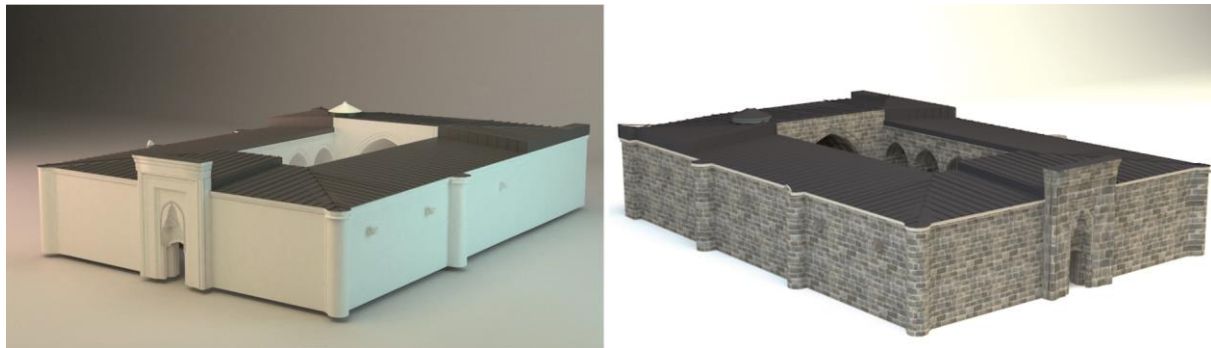Fig. 1. (a) Hunat Madrasa Reference Overlay; (b) Hunat Mosque Reference Overlay

Fig. 2. (a) The Three-Dimensional Model of Hunat Madrasa; (b) 3D Model of Hunat Madrasa, coated with texture

The three dimensional digital models of the buildings were created using polygon modeling methods on reference overlays. The three-dimensional digital model (a) of Madrasa and its current model coated with stone texture (b) are provided in Figure 2.

As the three-dimensional geometries will be render in real-time in the software, Polygon budget is considered important. The high-level resolution of the model affects display performance in the applications such as computer games and simulations, where the image is created in real-time. After the model is created, the polygon count can be optimized depending on the needs; however, it is a good approach to modeling with low polygon from the beginning (Strong B., 2008:21). Therefore, the models of the buildings in Hunat Complex were created using polygons as few as possible in the beginning. While the walls with few details were modeled using a small number of polygons, the detailed elements of the buildings such as muqarnas (a geometrical ornamentation that resembles stalactites,) covering systems and mosque domes were created using relatively higher number of polygons. Thus, the geometry of the building was created with multi-resolution. The photos and the three-dimensional models of the muqarnas covering systems on the Mosque east (a) and west (b) portals are given in Figure 3. Figure 4 shows the photo of the muqarnas covering systems on Hunat Madrasa Portal and the three-dimensional model created (a) and the photo of Hunat Mosque Dome and its three-dimensional model (b).
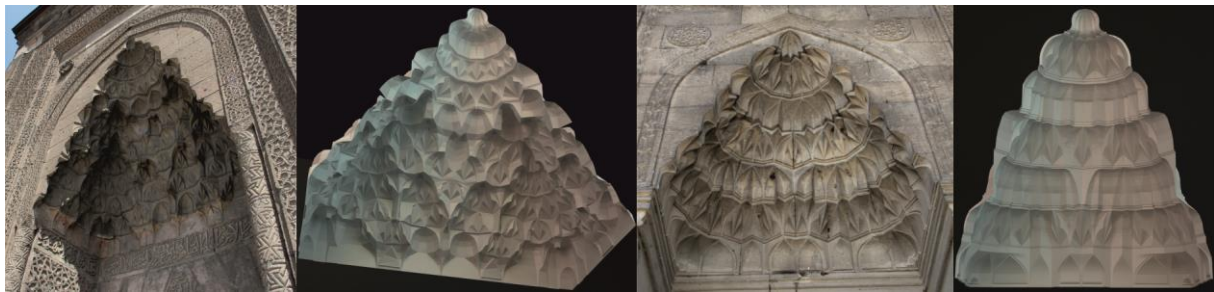
Fig. 3. (a) The photo and 3D Model of Hunat Mosque West Portal Muqarnas; (b) The photo and 3D Model of Hunat Mosque East Portal Muqarnas

Fig. 4. (a) The photo and 3D Model of Hunat Madrasa Portal Muqarnas;   (b) The photo and 3D Model of Hunat Mosque Dome

Another factor that reflects the characteristics of the buildings is the decoration. There are stone ornaments in the madrasa and the mosque. The ornaments in the mosque can be seen on the portal doors and the mihrap (niche) (Okur O., 2011:20). The Madrasa portal was the element most densely decorated in the madrasa. Moreover, a limited number of ornaments were used on the muqarnas on the main iwan, the circular badges composed of geometrical patterns on the doors of the rooms next to the main iwan, and the belts inside the entrance iwan. The density of the ornamentation was mainly on the portal doors in both of the buildings. After being modeled based on their original design, the ornaments were put on their location on the three-dimensional building model.   Figure 5 provides various examples of the ornaments modeled.
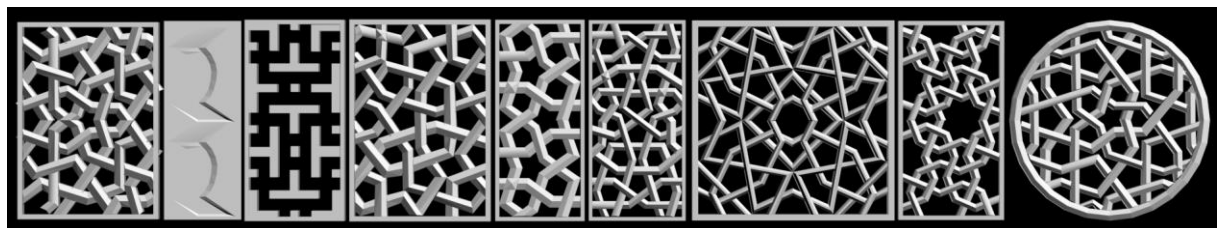

Fig. 5. Examples of the geometric decorative motifs in Hunat Mosque and Madrasa.

The structural and decorative elements in the model were divided into groupts and numbered with IDs. These ID numbers were used as the reference numbers in the interaction of the dynamic information windows in the software developed.

3.2. Fixing Surface Errors

The correction of the mistakes related to geometry due to the vertices, edges, and faces was done. These mistakes in three-dimensional geometries are the mistakes known as the cases of *overlapping*

faces, stray vertices, unwelded corner and *T-Junction* (Strong B., 2008:21). These mistakes affect the display performance adversely by keeping the model from being viewed in the software partially or increasing the number of faces unnecessarily.

3.3. Creating the Texture Maps

The photos of the buildings were taken to create the textures and these photos went through various stages in order to convert them diffuse and bump maps. The lens distortions in the photos taken were corrected with *Matlab Camera Calibration Toolbox*. Then, using the *Image Processing Toolbox* on Matlab, the angle photos were transformed to projective photos with the *Image Registration-Projective Image Transform*. Thus, they were converted to have front perspectives. The photos whose lens distortions and angle mistakes were corrected were transformed to textures as a whole or raport using the image processing software. Moreover, the brightness/contrast/intensity values of these images were adjusted to obtain better images.

3.4. UVW Mapping

While applying mapping coordinates to the faces, it was ensured that the textures were of appropriate size, direction, and tile. Mapping coordinates are expressed using U(horizontal),V(vertical),W(depth) dimensions and defines how texture maps are aligned to an object surface (Murdock, K. L., 2006:631). For these buldings UVW Mapping and Unwrapping modifiers are used to define the mapping coordinates. UVW mapping is useful for object with low detail (wall, column etc.) and Unwrapping is useful method when you need to apply mapping coordinates in sub-object level seperately for a complex geometry (muqarnas, arch, prov.gutters etc.)(Murdock, K. L., 2006:635).

The UVW Mapping created on the building of Madrasa is provided through Checker Map in Figure 6. The pre-viewing of the model on the game engine was done with the software, Away3D (Fig.7). In this stage, the factors that might affect the result such as the scale of the model, the pivot point location of each element, the size/direction of the textures and the normal direction of the faces were checked, and the necessary changes were made to use the model in the software.
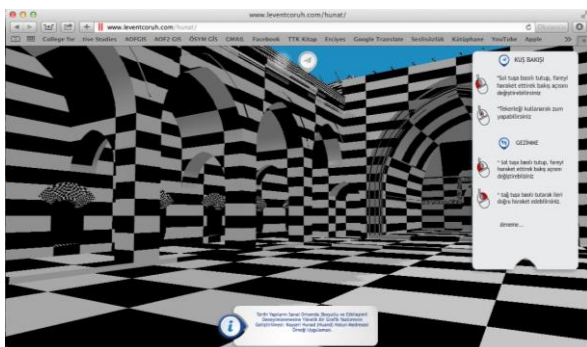

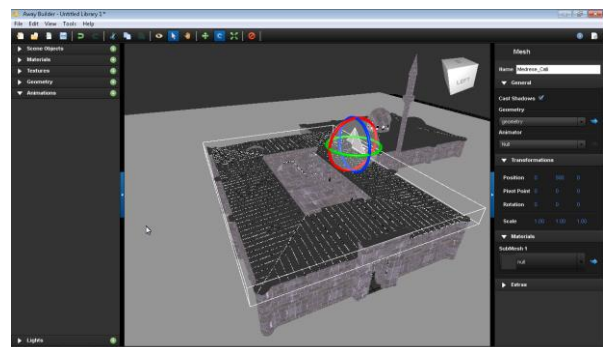Fig. 6. Screen Capture from Hunat Madrasa with checker map in First Person View Mode

Fig. 7. Preview with texture on Away3D

4. Developing the Software

The software, developed as an education model, was created within the research project entitled "Developing a Graphic Application that Will Allow Experiencing Historic Buildings in a Three-Dimensional and Interactive Environment: The Example Application of Kayseri Hunad (Huand) Hatun Complex", which was supported by the Coordination Unit of Scientific Research Projects at Erciyes University in Turkey. The software has been developed as the multi-platform with open source codes using Action Script 3 programming language, Air SDK and Away3D SDK in the development environment of Flashdevelop supported by OpenGL ES2.0. The development process of the software is provided in the work flow diagram in Figure 8.

The software was developed based on modes of first person view, walkthrough, and orbiting around the building with a bird's-eye view. The icons of walkthrough and Fly were placed in the interface for the switch between these two modes.

Static and dynamic information windows were included in the software interface. Static windows include a help window hidden on the top of the interface. When the Help icon on the screen is clicked on, a window appears on the screen, and when clicked on once more, it is hidden in its former place. The help windows include information on the control settings of the mouse and the keyboard. In the same way, there is an icon of Info on the right side of the screen. The window opened by this icon includes brief information about the software(Fig.6).
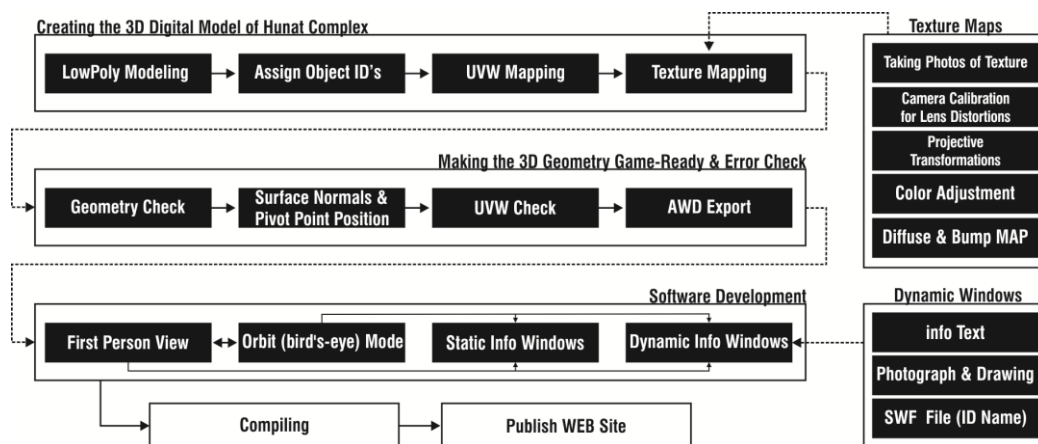

Fig. 8. The Work Flow Diagram for the Development Process

Dynamic windows are the windows that allow the user to reach the information on the structural and ornamental elements of the building. There is textual information on the photos, drawings, historical, materials, and the production technique of the related object in the dynamic information windows. These windows are opened when the three-dimensional geometry of the element in the building such as muqarnas, ornamentation, and inscription is double clicked on. The IDs assigned to the elements of the building during the modeling stage check whether there is an information window related to the object double-clicked on by being checked in the double-chick event. When there is a window available, they make the window appear on the screen; however, when there is not any, no action is taken. The dynamic information windows were named after the ID of the element and saved as flash (swf) files having different contents. The software code was written so that it would call and

display the corresponding window in the interface based on the ID of the element. Both the dynamic and static information windows work on both sides of *first person view* and *orbit*.

5. Conclusion

This software was developed by taking the aforementioned features to be used during the training entitled "making on-site inspection by visiting historic buildings" in the museum education course. The software was prepared so that it would carry the features that correspond to the topic identified by the expert of museum education and to student abilities as well as being easily accessible. The software presents Hunat Hatun Complex to the experience of audience, reflecting its glory with its plan, structure, and details. This educational material available in the virtual environment provides students to examine the building in detail with the help of just a few keys and a mouse. Moreover, it can be easily accessed on the Internet. Considering all its features, it is seen that it has reached its goals. This product has made it possible to experience the building in the virtual environment anywhere in the world via the Internet. It allows students and anyone interested to experience Hunat Hatun Complex via the computers at their homes and schools and mobile devices with Internet access by walking through its three-dimensional model in the virtual environment. The software provides an environment of rich experience by allowing single users to visit buildings in a virtual environment with a human scale and to examine them with a higher scale.

To test the software, it was used as an educational material in a pilot application in Museum Education course. The results of this application, undertaken in another study conducted to determine students' experiences related to the virtual environment created, are summarized as follows (Karakus E., Coruh L., 2014).

- The software developed is quite effective as an enriching tool to increase students' motivation in the current activities in the course, rather than an alternative tool to the physical experience of buildings.

- It acts as an effective material in terms of understanding, in particular, the plan and space relationships of the building.

- This virtual reality application is useful as a tool that students can use to have preliminary information about the building they will visit before the activity, to examine the elements that they see in the building in real time through tablets and smart phones, and to do practice again following the activity.

Moreover, various ideas were put forward based on the researcher observations during the study to improve the current application. The current application can be enriched by adding several features, such as turning the virtual reality application into a multi-player application, integrating a chat system into the application where users can send instant messages to each other, adding 3D characters to be used as avatars, adding historic characters (bot) that will inform the participants, and adding sunlight simulation. Creating the models of other historic buildings in three-dimensional and interactive virtual environments using this method and making these accessible on the Internet to the experience of all interested, mainly students are recommended as to increasing the availability of similar invaluable works.

References

Franson D., & Thomas E. (2007). *Game Character Design Complete.* USA: Thomson Course Technology.
Gahan A. (2011). *3ds Max Modeling for Games*, USA: Elsevier (Focal Press).

Coruh, L. & Karakus, E., O. (2016). Developing 3D graphics software as educational material for museum education course (The case of hunat social complex), *Global Journal on Humanites & Social Sciences.* [Online]. 03, pp 657-666. Available from: http://sproc.org/ojs/index.php/pntsbs

İsman A., (2003). *OgretimTeknolojileri ve Materyal Gelistirme [Instructional Technology and Material Development].* İstanbul: Degisim Yayınları.

Karakus E., & Coruh L. (May 2014). Determining The Differences Between The Experiences In Physical And Virtual Space Environments Through Students' Perceptions (Museum Education Course - The Example Of Hunat Complex). The Anadolu International Symposium On Arts Education "Transformations In Art Education", Eskisehir Turkey.

Murdock, K. L., (2006). *3ds Max® 8 Bible.* USA: Wiley Publishing, Inc.

Okur O. (June 2011). *Kayseri Anatolian Seljuk Period the Geometric Decorations Decorations in Mosques (Stone Decoration).* M.Sc. Thesis. Erciyes University, Institute of Social Sciences. Kayseri, Turkey.

Strong B. (2008). *Creating Game Art for 3D Engines.* USA: Charles River Media Publishing.