Augmented Reality in Character Modeling Education as Course Material

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Biography

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Abstract

In this study, an approach to the development process of an Augmented Reality based innovative course material is proposed. This approach is explained through a sample application developed for digital character modeling course.

In the traditional method, the character modeling education is carried out in three-dimensional (3D) virtual environments as its nature, while the artist or tutor controls these works on two-dimensional (2D) screens. Students follow what tutor does as a passive audience. The screen and point of view are controlled by the teacher and there is no control of the student on the virtual environment. For this reason, the student cannot participate actively in the majority of the course and this leads to the learning by doing.

The methodology used for the course material has been inspired from the ADDIE (Analysis, Design, Development, Implementation, Evaluation) method. The educational needs and the new possibilities of the AR were analyzed to develop a course material. This step aims to define outcomes of the course according to needs.

Features of the software are smart phone and google cardboard compatible, offering a shareable experience between teacher-student-student, 3D virtual environment that can represented within the physical world, students can monitor the progress of the modeling work on individual controls with phone-compatible bluetooth device (rotate, zoom, navigating through the modeling stages), managing virtual objects through physical objects (orbit), it is possible to explore the relationship between the physical reference (blueprint) and the virtual model during the modeling phase through virtual images superimposed on the physical medium.

Keywords

Augmented Reality, Digital Technologies, Higher Education, Classroom Integration, Character Modeling.

Introduction

Augmented reality (AR), which is one of the sophisticated digital technologies, has been proven to be an enormous potential in education as well as in many other fields (Bacca, Baldiris, Fabregat, Graf, & Kinshuk, 2014). Despite this potential, how to integrate with education has always been among the most fundamental problems. For the end of the 1990s as the early years of these technologies, McKenzie emphasized that infrastructure and equipment were provided but the educational part was incomplete (McKenzie, 1999; Joyce, 2005, p.52; as cited in Wilks, Cutcher, & Wilks, 2012, p. 64). Today, we still face the problem of how this educational part will be integrated by others. Thanks to information from previous practices and research in the field of art and design and other fields of education; We know that the diversity of educational content and needs necessitates authentic solutions for each situation rather than a standard solution (Prensky, 2001, p. 150).

In today's society, technology has become a part of life and the methods of producing and using knowledge have changed (Antonioli, Blake, & Sparks, 2014, p. 96). As quoted by Hestick (2014) from Blackwell (2012), the educators who are inspired by the development and survival of today's youth under the influence of daily digital technologies are making considerable efforts to integrate these technologies into classroom learning experiences. Educators are faced with unique challenges when trying to find meaningful ways to use digital media in the classroom (Watson & Pecchioni, 2011, p. 307). Nevertheless, these digital technologies and the efficient cooperation between visual design and art education are not always easy to achieve as in many fields of education.

In his six-point methodology regarding the maintaining of the cooperation, Fernandez (2017) highlights certain subjects such as education of teachers on this subject, the development of conceptual prototypes, teacher-computer programmer-education programmer (architect) team work, production of experiences that can be used in the next real situation, teacher's use of it in his/her own teaching methodology within a possible subject-specific experience, and the use of this experience in regular education with students. As can be seen, a group of obstacles such as prohibitive policies, inadequate infrastructure, curriculum requirements, and insufficient professional development of teachers (Herro, 2015, p. 117), planning, software development and equipment problems can be mentioned in the realistic integration of educational content in virtual environments. Any change can be intimidating such as starting use of digital technologies in classroom (Hedberg, 2011, p. 5). Aside from teachers who are biased or resisting against new technology (Huang, 2016) by the teacher, teachers and students will need additional time to learn the use of equipment such as VR and AR even if they are willing to do so (Boyle 2017, p. 6). Besides, it will require arrangements in the curriculum that will enable this.

How and by whom these practices should be developed is a separate question that needs to be clarified. Because many teachers do not have sufficient time and technical skills to create their own AR / VR applications, third parties are needed to produce the necessary programs and put them into content (Choi, 2016). Only the teacher and computer developer can produce solutions to meet the needs of a course, but it is important that field experts, such as educational programmers / architects, can also participate in this collaboration in terms of organizing an entire curriculum in regular education.

This study focuses on innovative course material development processes and therefore how a meaningful integration between the courses in the design education curriculum and AR technology can be achieved. The departure point of the study is to analyze a pilot lesson in the graphic design education curriculum, to develop a functional approach for educational software design and to demonstrate a working prototype software in this way.

Throughout this study, the educational software design developed for the 3D Character Modeling and Animation Course, which is taught as an elective in the 4th year program of Erciyes University, Faculty of Fine Arts, Visual Communication Design Department is produced as an AR-based software. The software was developed as a supporting educational material for the theoretical part of the course. The aim of this application is to prepare an environment in which the student is actively involved, with high learning motivation. Expectations from AR-based course material are that the students stay active, that everyone in the course has equal control over the visual material (content), that the audio-visual communication in the classroom environment continues - there is no isolation like in the VR (Liou, Yang, Chen, & Tarng, 2017, p. 110), addressing different levels of comprehension, brief the ability to do the brief section in class-free environments can reduce the tension of the students in the lab. As quoted by Karolčík, et al., (2016, p.9) from (Jeet-Kaur & Sharma, 2013; Owusu et al., 2010; Nagy et al., 2012), previous studies have shown that the digital technologies in the teaching process increases the students' motivation and their interest in class. The software is intended to be developed not as an alternative to traditional teaching, but as a solution to the situations in which the course is subject to difficulty (such as difficult subjects, low motivation, etc.).

The software can be realized with the cooperation of a course teacher, field expert academician and a software engineer. The study was carried out within the scope of NAP-SBA-2018-7583 research project funded by ERU Scientific Research Unit and it was possible to overcome the budget problem corresponding to the contribution of the mentioned third parties to software development.

In addition to hygiene problems associated with common use by many students in Virtual Reality environments, Choi (2016) and Wu et al. (2013) asserted that the fact that most of the risks that require sensitive planning such as failures in the VR device due to increasing number of students and computer crashes are not in AR, make AR more easily integrated into the classroom environment than VR.

Kapp and Balkun (2011) has been described AR technology as accessible to everyone and as an incredibly cheap technology due to the needs that can be found easily such as internet connection, computer, a printout and a web cam. Nowadays, thanks to the development and spread of technology, things on this list have been reduced to a smartphone with internet connection only. The centralized and graphics processors of smartphones competing with computers have become much more accessible with new cameras, including superior cameras and the new environment of the AR, which recognizes the physical environment of the AR.

Almost all of the students included in this study use smart phones. Due to the widespread use and popularity among students, an application for smartphones instead of tablets has been developed.

Determining the Course Activity's Needs

The misconception of seeing these technologies as their primary target, not as innovative tools for the development of students' outcomes in learning processes is the main risk in this integration effort for VR and AR (Fernandez, 2017). Hence, it would be the right approach to start developing from the needs of the course, not from the possibilities of AR technology.

The following questions were sought before starting the software design;

- How AR technologies can serve the goals of this course?
- In which parts of the course can AR technology make a difference?
- How to integrate AR technology into course work?

In order to find answers to these questions, the course syllabuses were examined and the lecturers who conducted the course were interviewed. In this part of the course, students were asked about difficulties in terms of student motivation, difficult to express concepts, transfer of knowledge etc. In addition, if there is a quota for the course, the maximum number of students and the average number of students in previous years were asked.

The instructor pointed out the theoretical sections as the section in which the students were passive listeners rather than active participants; and the brief sections of the 3rd, 4th and 5th weeks as the sections in which motivation falls. Also, he pointed out the 13th week in which graphical tools and abstract concepts are processed related to tracking the relationship between motion and time as a section where students have difficulty in understanding. It was stated that the quota of the course was 17 and the number of students was between 15-17.

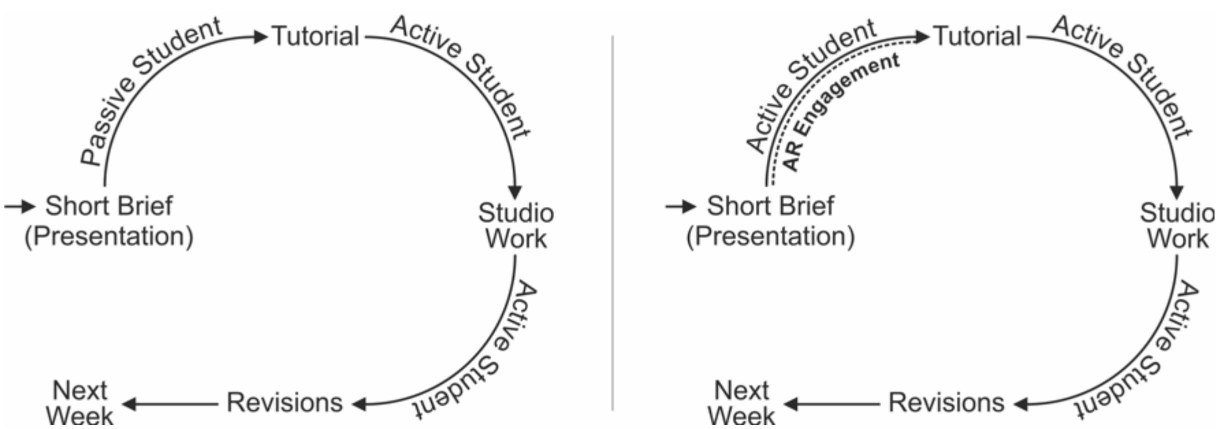
Through the analysis of the course syllabuses; it has been observed that the course structure has a closed cycle consisting of theoretical expression, tutorial, student practice, revision proposals and repetition of these stages.

In the first week of the 15-week program, parametric modeling, NURBS, Spline, Polygon as a general description of three-dimensional modeling methods are given. In the second week, specific concepts related to polygonal surface modeling with specific blueprint method and polygon modeling tools of 3D Studio MAX software were studied. During the next three weeks, the students conduct a studio study for modeling a character under the guidance of the instructor. The studio study is followed by the short brief of the instructor and then concurrent tutorial and the student practice. After the fifth week, during the weeks other than the 13th week (6-15 weeks), the topics related to the Character Studio system are emphasized. On the 13th week, there is a focus on issues such as Animation Track Parameters (Track View) and motion accelerations for movement and time relationship.

Due to the fact that the content of 3D imaging and interaction within the AR and the digital three-dimensional content of the course are overlapping and can be easily integrated into the relevant part of the course, it has been decided to develop AR as an application aimed at contributing to the increase of low motivation in the brief sections of the 3rd, 4th and 5th weeks.

The instructor will explain the relevant parts of the structurally appropriate and robust modeling approach for the animation and play environments and the stages in which the course will proceed at the beginning of the lessons in these weeks. In this part of the course, in the traditional method, the instructor explains the subject with the slides of the related stages. The lecturer is active narrator and students are passive listener.

Through the integration of AR software into this course, where student motivation has fallen; instead of being passive listeners, students are aimed to become active participants who have their own controls on the content. The visual content offered to the students to remain active requires mechanisms to ensure the direct interaction of the students. The parts in which the students are active-passive and the expected situation after the integration of the AR-based course material are given as flow diagram within the current course flow of the selected weeks in Figure 1.



a. **b.**

Figure 1: **a.** Traditional, **b.** AR Integrated Course Flowcharts For Weeks 3,4,5

Designing Software

After the educational needs were determined and the target became clear, the following questions were asked on how to achieve this goal;

- What are the features that should be in the software?
- What kind of digital content should we use in AR?
- How will the course content and topics be given with AR?
- Which of the new opportunities come with AR serves the purpose of the software?
- Which parts of the course content and topics will be transferred to AR?
- Which Platform?
- What kind of mechanisms of interaction?

The answers to these questions were sought and the following findings were determined.

The Necessary Features of the Software (Based on the Needs of Course Activity)

During the course, the modeling process is shown in stages. Digital content should also be able to show these stages.

Blueprint method is an approach in which model geometry is developed based on reference drawings. In this sense, the course content is explained by the development stages of the model and the consistency of the reference drawing visuals. The digital content to be produced should be designed in such a way that students can follow the model-reference drawing relationship.

The course should be able to show the geometry of the three dimensional model due to its nature.

In the traditional method, the student is a passive listener when the teacher makes a theoretical expression. In the course of theoretical instruction, it is necessary to ensure that each student attends the course to be active in contrast to the traditional method. There should be mechanisms for interaction with digital content for students. These mechanisms should allow controls such as rotate the model, zoom in / out, navigation (between model phases), wireframe / shaded display, reference image display, and description text.

As the individual control of the students is possible only by visual display of individual content for each student, an individual screen is required for each student. For this reason, students should be able to work on their smart phones / tablets.

Creating the Digital Content

3-dimensional digital models for model production stages, bitmap images for reference blueprint drawings, and text format for explanations of stages were used as digital content.

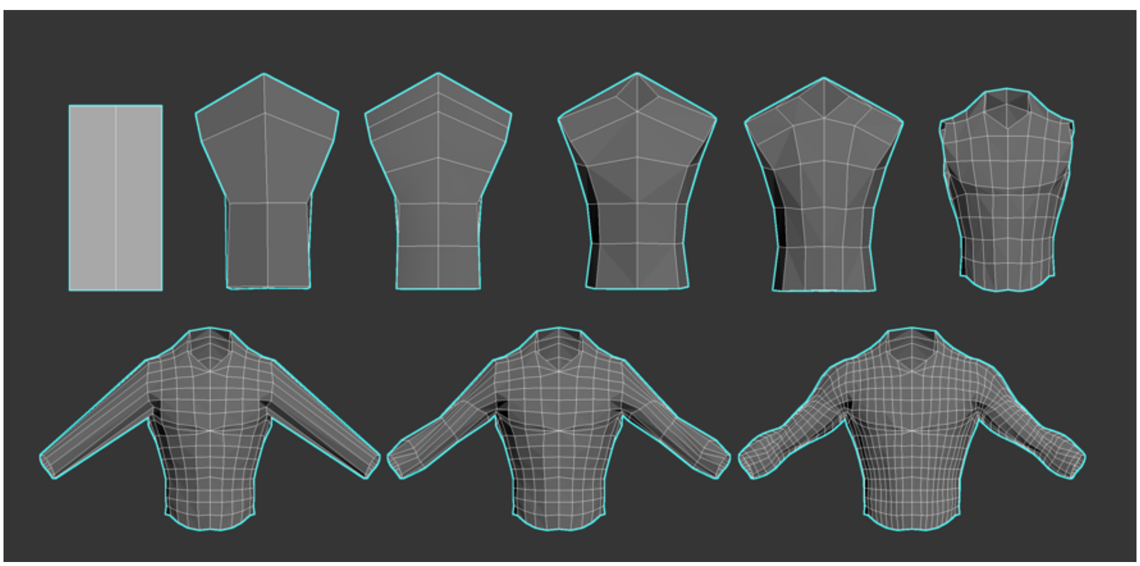


Figure 2: Sample Stages from Model Production Process

Creating the Three-Dimensional Digital Models

In 3D Studio Max software, a separate model is produced for each stage of the modeling work, starting from a simple box object to the completed character model. While the development of the model was progressed step by step, each step was copied and named according to the sequence number in AR application. Figure 2 shows the example stages that demonstrate the development of the model.

In order to transfer generated models between Unity and 3dSMAX softwares are used in the FBX file format which is supported by both software packages. Models are exported in FBX format with geometry and Material properties.

Texture Maps & Materials

During the lecture, color accent is used to emphasize the polygons spoken on. Multi-sub Object type material and Materials modifier are used to display the polygons of the model in different colors. Thus, there is no need to produce separate UV expansion and texture file for each model.

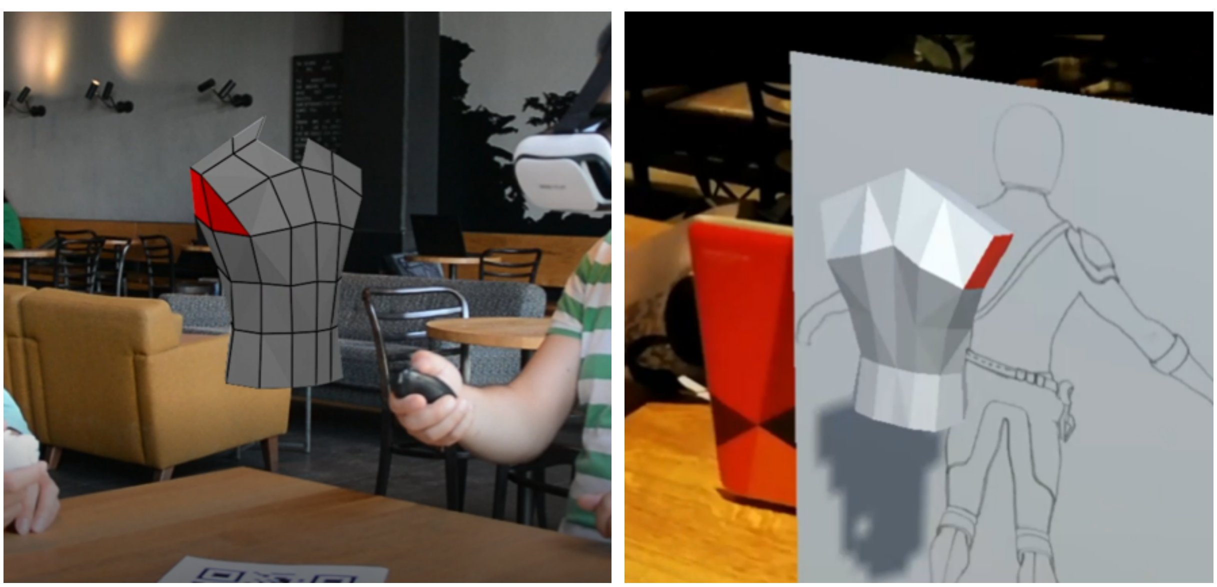


Figure 3: Color Highlighting of Polygons

In this method, it is intented to be spared of both the workload and the amount of data required to be installed on the smart phone. The shading color is gray, and the highlight color is selected as red. Figure 3 shows the sample screen captions for the use of color accent.

Developing the Software

AR systems allow users to see and interact of perfectly spatial registered information with 2D, 3D or virtual markers (Biocca, Owen, Tang, & Bohil, 2007, p. 164). *Vuforia library was used for image processing. At the beginning of the development phase, Markerless method (Ground Plane Stage) was used for the relationship of physical objects and CG objects. This method can place objects on these planes by associating virtual objects with the planes that they perceive as ground without needing any marker. However, the libraries used by Vuforia for this method work only on high-end phones at the time of the study and do not support lower models. As many of the students use older model smartphones, the Ground Plane Stage method was abandoned for the time being and a former method, the Image Target method, was used to address a wider range of phone models.*

When the program is launched, the image from the camera is processed by the Vuforia ARCamera. According to the selected method (Image target, Object target, Ground Plane Stage, Vumark etc.) the target (pattern or ground) is checked whether it is recognized or not. If recognized, the initial objects are created on the scene. It is constantly checked whether 7 separate conditions have occurred in the software cycle (update loop). These conditions are Navigation, Scale, Rotation, Referance Images On / Off, Reset Rotation & Scale, Wireframe mode on / off controls that can be remotely controlled via bluetooth. If any of these conditions occur, the corresponding value is changed, and the cycle is refreshed as given in the diagram below.

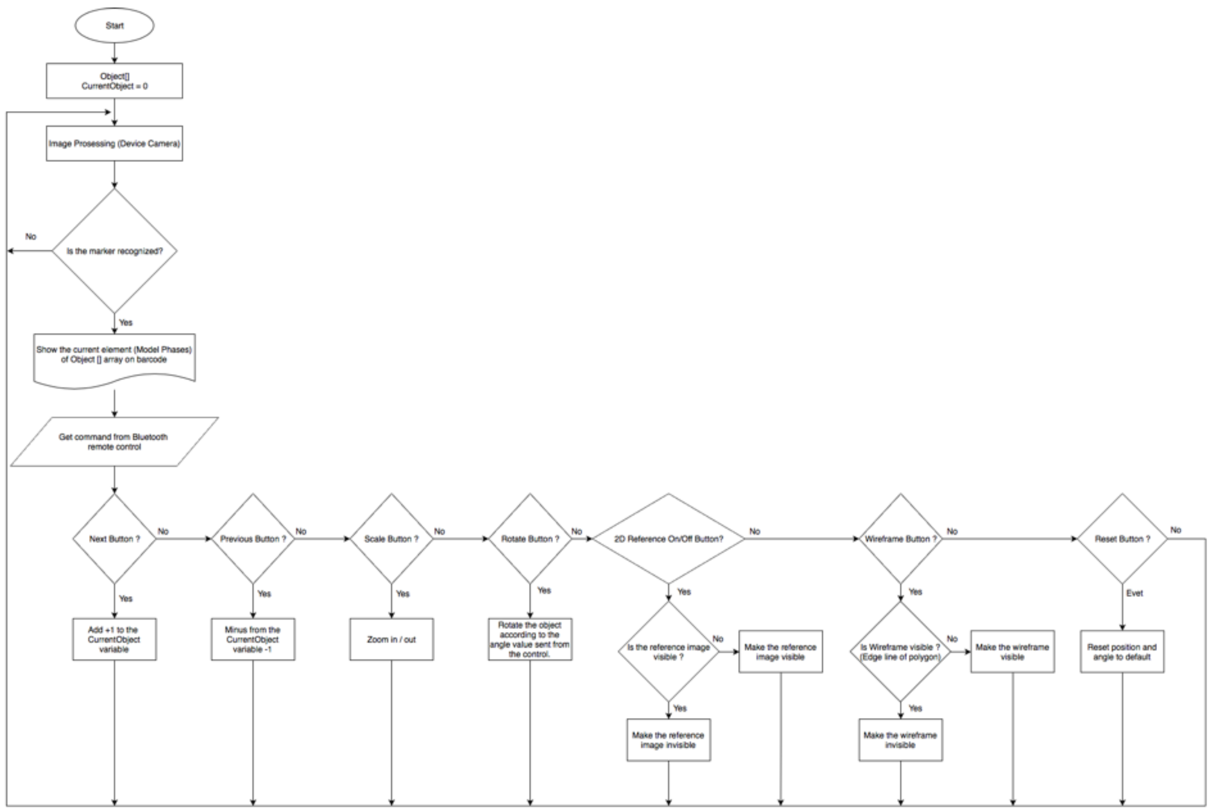


Figure 4: Flowchart Diagram of The Program

Stereo Display

The ARCamera object of the Vuforia library is used to acquire the image from the camera. By default, ARCamera displays the image on a single screen. The following additional method has been developed to divide the screen into two equal areas by dividing the screen into two equally normal screens.

Through this method, the image taken from ARCamera is assigned to RenderTexture Object instead of the screen, then two separate RawImage objects are created in the UI Component for the right and left eyes. After the RawImage components are placed side by side on the screen, the Anchor feature allows the image to be stretched for all possible screen resolutions. Finally, the image in the RenderTexture Object is assigned to the Texture property of these two

Figure 5: ARCamera Default Display Method Diagram.

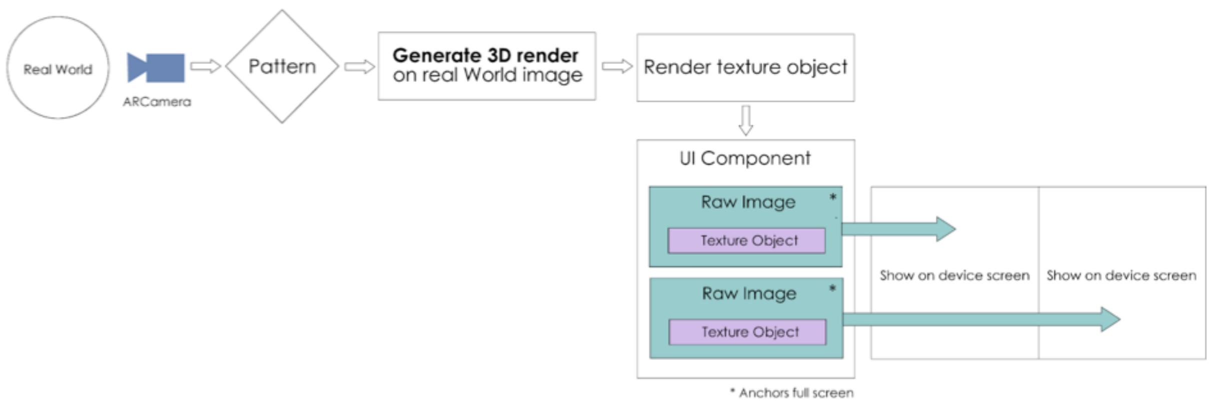


Figure 6: Stereo Display Method Diagram

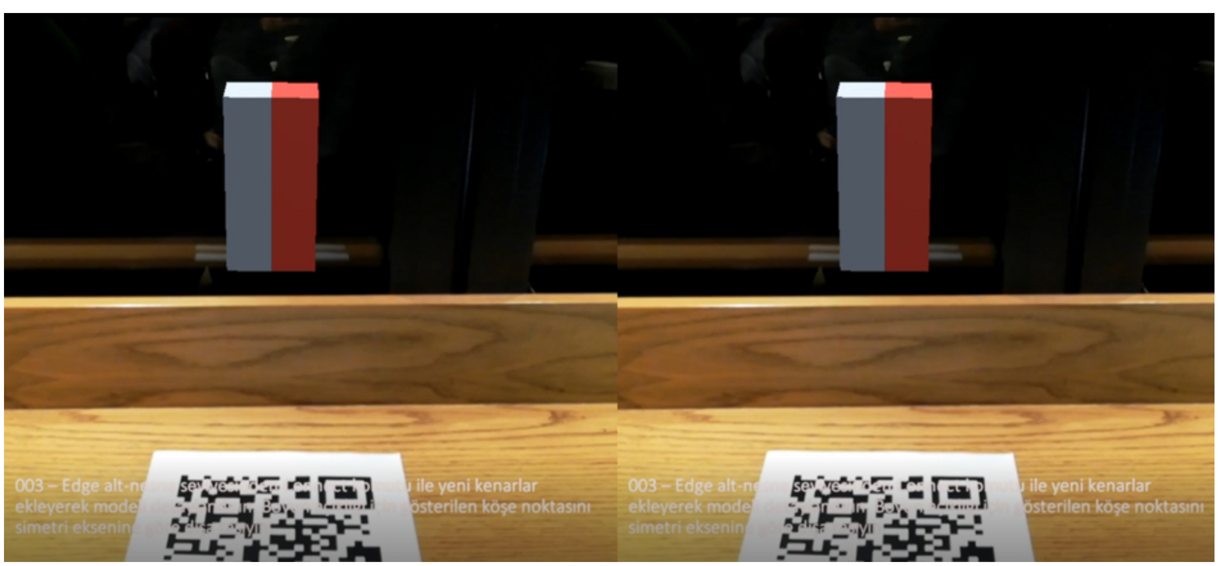


Figure 7: AR Application Stereo Display Screen Capture

RawImage Components to complete the process. Figure 6 shows the Default Display Method Diagrams for ARCamera and Figure 7 shows the Stereo Display Method Diagrams developed for ARCamera alternatively. Figure 8 shows a sample screen capture from AR application for stereo imaging.

Importing Models to Unity & Converting it to Prefab Objects

When the normal object is added to the scene, the components and features used with prefabricates cannot be used. Models must first be converted to Prefab objects for features such as Create and Destroy of the models through the code on the stage (in runtime); management of the coordinate and scale information.

For this reason, the model stages are first imported as Asset, then new Prefab objects are created from these original objects imported in FBX format. Although prefab objects are used with code in the scene, the original model should be stored as source object in order to manage the Scale , etc., properties.

WireFrame Display on Shaded Model Geometry

Although the geometry of the model is detected in a shaded representation, it is necessary to display the wireframe so that the polygon topology can be read clearly. In order to display the borderline of the polygons on the shaded model, the additionally installed Wilberforce-WireframeDX9 is added to the shader software. Using these shaders, the shaded polygons can be displayed with the desired color and pixel thickness. In AR application, the green color is selected to separate the Wireframe mode from the standard display. Thus, it is intended that the features not included in the standard notation such as color accent are not missed by the user. The screen caption from Wireframe display is given in Figure 4.

Figure 8: Wireframe Display with Wilberforce-WireframeDX9 Shader

Object Positioning, Alignment and Scaling

The scale is relative depending on the values such as the distances, positions, dimensions, FOV value of the camera and the virtual camera. The position and size of the models are adjusted to the best by the Cardboard glasses on the phone display. As a first step, a virtual camera and an Image Target (or Ground plane) are positioned in Unity space. Then, the objects to be displayed

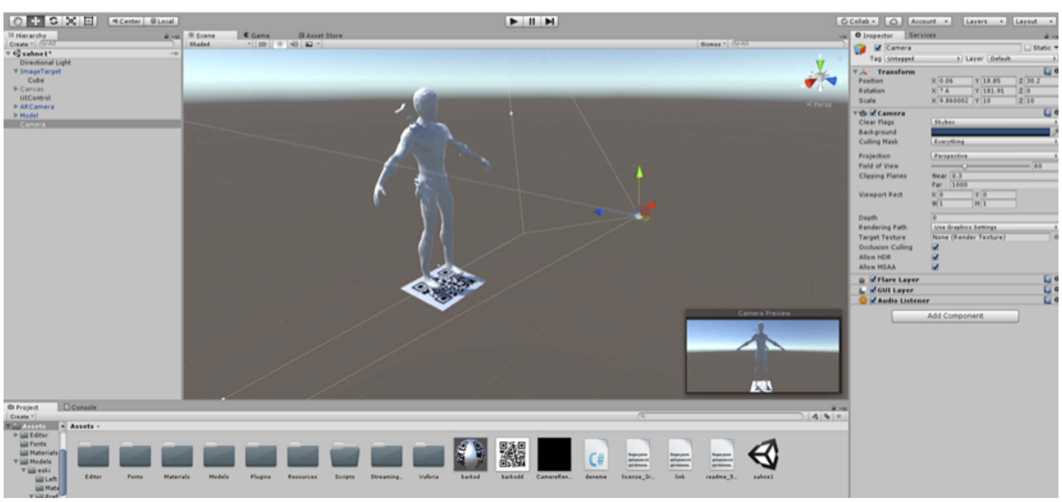


Figure 9: ARCamera, Image Target and 3D Object placements in Unity Screen

are positioned, aligned and dimensioned according to the Image Target (or Ground plane).

Parametric Design

In order to increase and decrease the model stages in a parametrical way, an Array parameter which the number of elements can be changed is created. The required number of elements can be assigned to the prefabricated models from the Unity interface. Adding, sorting and changing the steps with parametric structure are possible without interfering with the code. Figure 10 shows an array of 18 elements and transform type objects assigned to this array.

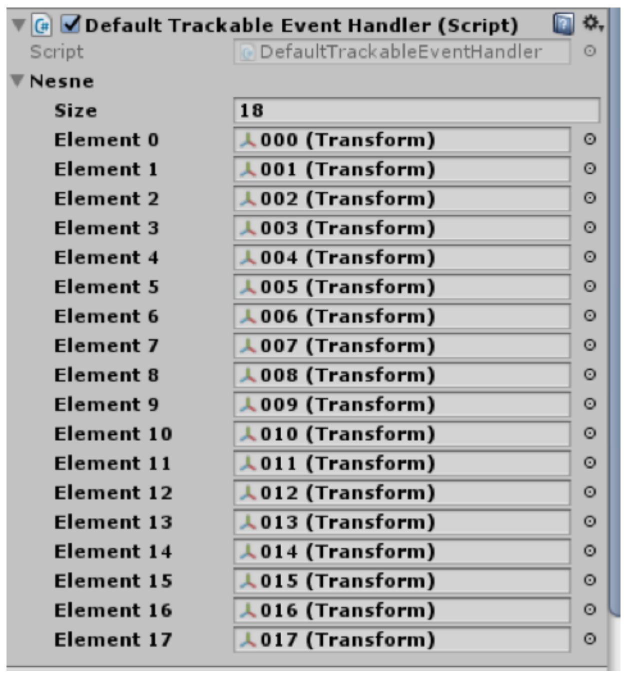


Figure 10: Transform Array List for Model Phases

A string array is defined for the **description text**. The array element matching the model sequence number is displayed as a description for the corresponding stage on the screen. Figure 11 shows a line of code for the description text that matches each element.

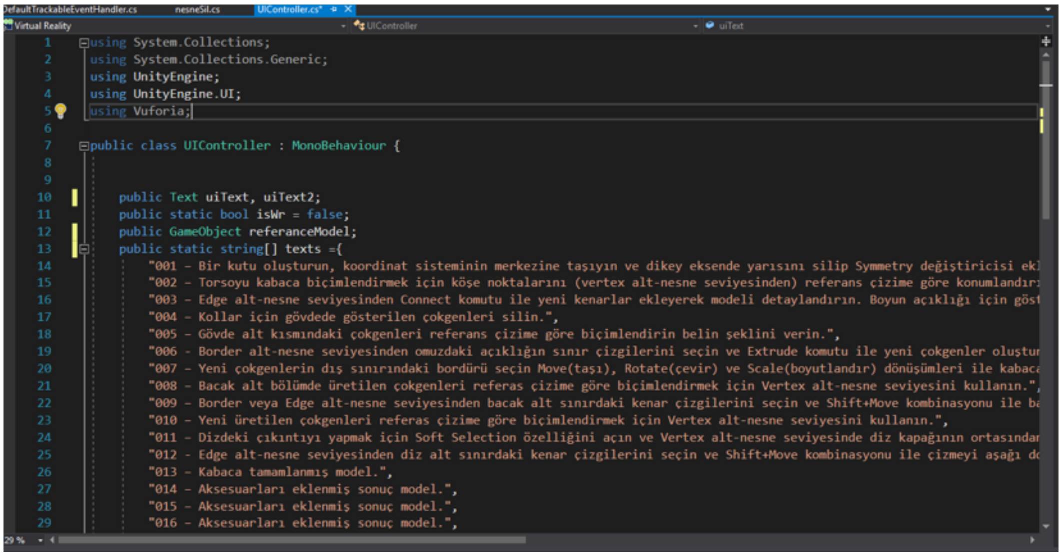


Figure 11: String Array for Model Phases

Memory Management

Using the scene with all models installed on the stage may cause memory limits and performance problems for some smartphones. To overcome this problem, the structure of the program is designed to load only the first-order model after running the program on runtime. With this method, when a new model is to be displayed, the current model in the scene is deleted and replaced with the next or previous model. In this way, memory and rendering computation power are used for one model at a time. Thus, it was possible to avoid problems related to the Polygon budget, such as memory and rendering time.

Interaction

As the marker-based method of AR is used in the software, the interaction of the user with the pointer paper in the physical environment directly manipulates the digital layer. When the user rotates the paper with the barcode image, the model that is digitally connected to it will also be rotated. However, Kapp and Balkun (2011) stated that the next good thing about the

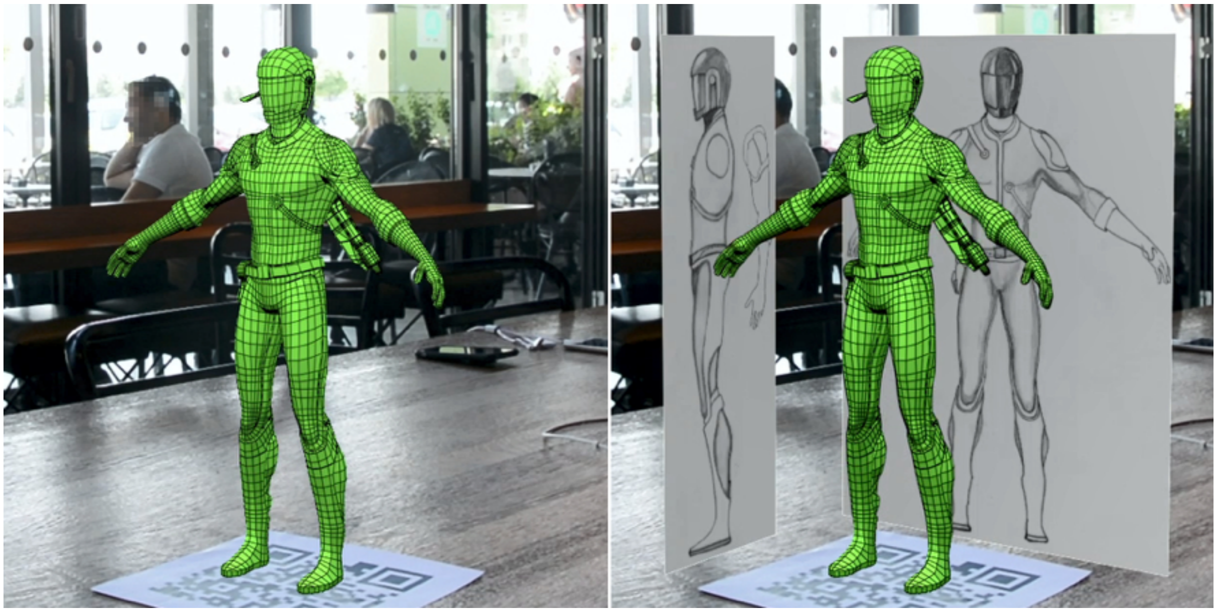
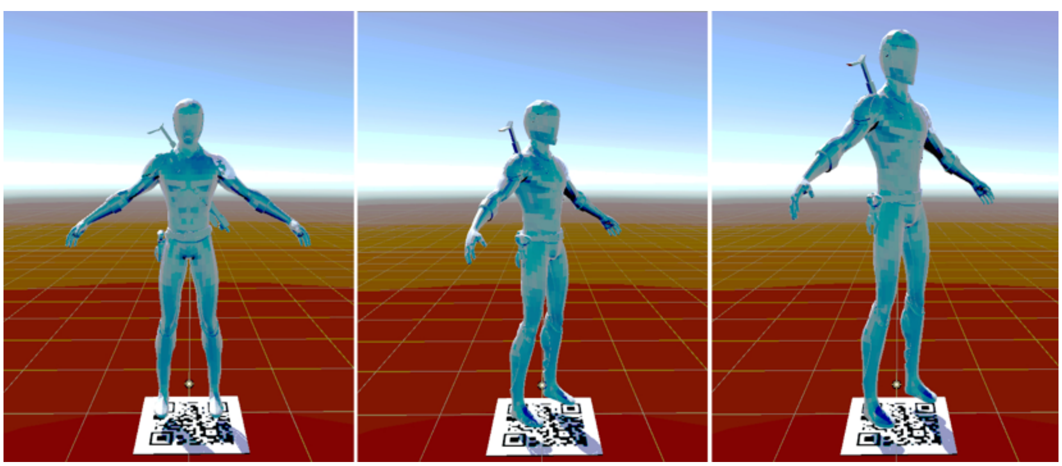


Figure 12: Display Reference Images Feature



a. **b.** **c.**

Figure 13: Rotate and Scale Features; **a.** Default Angle and Scale, **b.** Rotated, **c.** Scaled.

Figure 14: Students working with AR application

integration of AR into classes would be to add an interaction layer to AR. In accordance with this approach; In the integration of the course and AR, it is preferred to follow a path where the user can interact not only with the marker but also with the digital content directly and adequately, instead of passive approaches such as those that are limited to the display of the animation of 3D characters on a children's book page. Thus, the advantages of a concept that can support practical learning can also be included in the software.

The application will not have user access to the touch screen because the smartphone is attached to a Google CardBoard compatible glasses. Therefore, the interaction between the software and the user is provided by bluetooth control. The controls to maximize the interaction between the user and digital content such as back and forth between the control and model phases, zoom in and out of the model size, rotate the marker paper independent model (Z axis only), reset the rotation angle and size to default, view and hide Reference sketch drawings, view and hide the border lines of polygons, display and hide description info are provided. The controls provided on the digital content via the control are given in Figure 15.

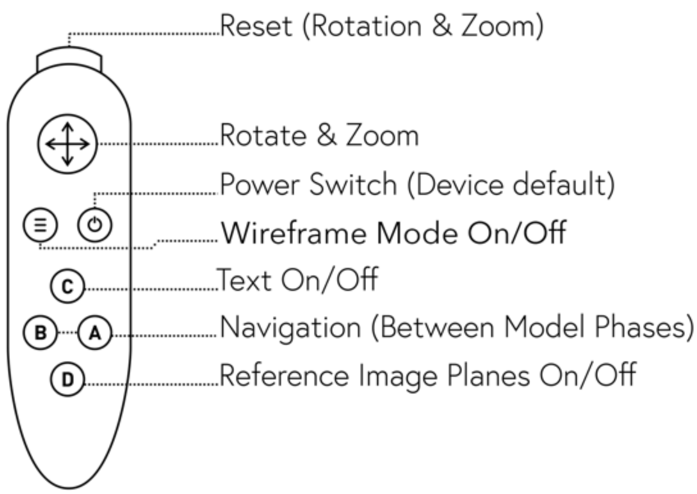


Figure 15: Summary of Software Features and Controls on Bluetooth Remote Control

Conclusion

Focusing on what it means to create meaningful educational contexts, rather than the eye-catching of these technologies would be the right approach while striving to build collaborations between new digital technologies and education. However, we can mention the concrete contributions of the mentioned innovative technologies to art and design education.

Through the course material development process with the project, software development, it has been observed that digital content production, budgeting and course analysis are separate processes that need to be handled separately, but need each other to create a whole and experience has been gained. In the light of these experiences, the idea that the development approach should be based on a four-legged structure, including needs analysis, design of software structure, digital content generation, and software development has emerged. Before starting to develop material, it is important to determine the need for integration of an AR-based technology to the course to achieve a meaningful educational content, to determine what kind of misalignment, if any, or to improve what is in the current situation. From this perspective, a reverse analysis process was conducted for the data that will be based on the course material design. Syllabus and course materials were examined, how the course level-flow was studied and how the course served the expected learning outcomes, negative factors were searched, and the workloads of the course, the number of students and the physical environment of the class were examined. In addition, interviews were conducted with the teacher of the course, difficulties were encountered in the course of the course, motivation was low and the students were asked about the situations in which there was no effective learning. Course diagrams of the determined weeks were taken and the activities in the course and the parts in which the students were active / passive and the parts that the teacher indicated as low student motivation were marked. It was determined to develop the AR-based course material in order to improve the negative conditions of the three-week course and to discuss the possibilities of AR and the ways to contribute to the solution of these problems and how to integrate them into the course.

After this stage, software design was realized. As a basis for software design; the needs of the pedagogical needs and objectives, conformity to the class environment, compliance with individual and group work, sustainability and extensibility characteristics were taken into consideration. The selection of the platform is determined by the possibilities of the devices to be used. Equipment facilities of the research institution points to the smartphones that are already available to students due to the lack of sufficient number of high-end devices such as hololens, oculus rift, or htc vive compared to the number of students. During the software development phase; The educational software that responds to many software needs and technical problems such as lack of AR and Stereo display support of Vuforia libraries, limitations due to differences of Android and IOS platforms, different screen resolutions / ratios in student smart phones - different graphics / memory capacities, the necessity of a parametric structure where the software teacher can change and improve digital content when the software engineer is out of cycle has been completed with the C # programming language in the Unity development environment.

In this study, there are currently methods that can interact with the nature of the AR by touching objects in the digital layer of the AR without the Bluetooth controls although the interaction between the digital content and the user has been made by a control that communicates with the phone via Bluetooth connection. For the time being, it is obvious that these advanced methods working for a limited number of phone models will be used frequently in many applications that require widespread applications such as educational applications and support for all phone brands and models.

It should be noted that AR / VR technologies are under continuous investigation, and people working in this area should be able to adjust their stance open to continuous change and renewal due to these developments. This means that the teachers who should be the sole users of these technologies together with the students should never stop learning, what new technologies are and what they should do with them.

It is not realistic to talk about a standard solution with augmented reality that addresses every lesson and even to talk about specific solutions to a course that meets all needs. The handling of course materials as units divided into specific modules in units and moreover selected units is a much higher approach to functionality than a standard solution. These modules can contribute to motivation and learning with their interaction or visual facilities by finding a short-term place of use in the required parts of the course. In this way, the negative effects of discomfort related to the duration of use such as cybersickness, also known as simulator retention (Strauss, 1995), will be avoided.

Finally, it is considered that the amount of benefits that AR / VR will provide to the education field will be increased thanks to the redesigned curricula including digital in an understanding that accepts innovative digital technologies as educational tools rather than the efforts to integrate new digital technologies into these traditionally prepared curricula for teacher education curricula (Keino, 2008, p. 5) and for art and design curricula in general to increase teacher competencies.

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