Effective Educational Augmented Reality Applications: Points to Consider

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***Abstract*— A new paradigm, that it is possible to access information in any place at any time, led education researchers to seek methods to permit interactions between the real environment and digital information. Augmented Reality (AR), which provides such an environment of interaction, was consequently developed as a technology that allows interaction between people and information. This technology promises significant potential if integrated into education. The purpose of this study is to present important factors to consider while developing an effective educational AR applications. The analysis, design, development, and implementation of educational AR applications are examined. This is a case study. The sample consisted of 42 senior undergraduate students, who had experience with educational AR technology. Structured interview form was used as the data collection tool. According to the findings, the participants focused especially on software selection in the analysis phase. They reported that easy interfacing of the program, multimedia support, the environment where the application is to be implemented, and the related devices to be used should be carefully considered. In the design and development phases, it is important to determine whether the application is appropriate to the target population, the content, and the purpose. In the implementation phase, it is important to provide the necessary technical sub-structure and the physical environment; to inform the students about the program, materials, purpose, and potential outcomes; and to provide them with equal opportunities in the application. The results obtained in this study can be used to guide future educational implementations and research studies on AR technology.**

***Index Terms*—Augmented reality, educational technology, instructional design.**

I. *INTRODUCTION*

A new paradigm, that it is possible to access information in any place at any time, led education researchers to seek methods to permit interactions between the real environment and digital information. Augmented Reality (AR), which provides such an environment of interaction, was consequently developed as a technology that allows interaction between people and information [1]. An important feature of AR applications is that they help to make participants active by encouraging interactions with simulations, games, models, and virtual objects. They also provide learning environments that support ubiquitous, collaborative, and situated learning. Finally, AR applications make it possible for invisible concepts and events, abstract concepts, and non-observable events to be displayed with the help of physical objects, animations, and virtual environments [1], [2], [3]. [4], [5], [6].

In spite of the advantages of AR applications, there are some pedagogical issues that need to be taken into consideration when AR systems are implemented for educational purposes. First, AR is a relatively new technology. Like many educational innovations in the past, its implementation might be hindered by constraints imposed by schools or resistance among teachers. The learning activities associated with AR are quite different from traditional methods. Also, instructional design is vital in AR learning environments. In some AR systems, the content and the teaching sequence are fixed; this is one of the pedagogical problems associated with this technology. Ideally, it should be possible for teachers to change the sequences according to their students' needs and the teachers' instructional objectives [7]. The number of applied and comprehensive studies conducted on the educational potentials of AR technology is rather limited in the literature. The reason is that AR is a newly developed technology, and so studies on its development are more common [6]. Considering this fact, it is important for researchers to apply AR technology in the field of education and to share their experiences in this process. The present study presents the experiences of practitioners who achieved an integration of AR technology into education. The purpose of this study is to present important factors to consider while developing an effective educational AR applications. The analysis,

design, development, and implementation of educational AR applications are examined.

II. METHOD

This study was designed as a case study. The case study is an ideal methodology when a holistic, in-depth investigation is needed.are required. The case study method was preferred in this study because it can be used to elicit detailed opinions from the participants [8]. The qualitative data were collected by means of a structured interview form.

A. Participants

The forty-two participants in the study were senior undergraduate students in the Department of Computer Education and Instructional Technology at Ataturk University. These students had taken the course "Project Development and Management" that was taught by one instructor and two research assistants. Student groups of 5 to 6 completed a final project on "AR in education". The project groups designed their instructional processes in cooperation with the teachers, using AR technology. They formed their projects based on the ADDIE instructional design model. They designed materials and instructional activities using AR technology in Level 1, which refers to 2D marker-based AR technology. The first type is the 2D Marker AR, which is PC and webcam-based. The marker is a black and a white square image that is printed out and held in front of a webcam to produce a 3D animation, a simulation, or a video. The other type is the 2D Marker AR with a mobile device. This involves a great deal of real time processing and a very capable phone [9].

B. Data Collection

The data were collected using a paper-based and structured interview form. This form was developed by the researchers based on a literature review and on the study's research questions. Interview form included 12 open-ended questions. The interview form was completed by each participant in the class (F: 20, M: 22; age range: 20-25 years). All of the participants volunteered answered the questions based on their learning experiences, which had lasted about three hours each.

C. Data Analysis

The qualitative data were analyzed with the content analysis method, using Nvivo 8.0 software. Themes were created, which were based on the research questions, and the data was presented with descriptive statistical methods.

III. FINDINGS

A. Points to pay attention to in the process of analysis

The participants focused especially on software selection in the process of analysis while developing educational AR applications. They reported that easy interfacing of the program, multimedia support of the program, the environment where the application will be implemented, and the related devices to be used should be primarily taken into consideration while selecting the software to develop an educational AR application. The collected data is shown in detail in Table 1.

TABLE I. POINTS TO CONSIDER IN THE PROCESS OF ANALYSIS

Points to consider in the process of analysis	
Points to consider	***n***
Easy interfacing of the software (defining, creating the markers, etc.)	20
Multimedia support of the program (pictures, audios, videos, 3D model support)	14
The environment where the application will be implemented, and the related devices to be used	14
Recognizing and displaying the markers (duration, number, image quality)	12
Software, and equipment necessary to run the software	12
The subject related to the application	12
The target population addressed by the application	12
Technical difficulties due to the software	11
The variety of file extensions supported by the software	9
Cost of the software	8
Internet support required by the software	7
Allowing interactive material development	4
Coding information required by the software	4

B. Points to consider in the process of design and development

The participants stated that the process of designing and developing an educational AR application, it is important to determine whether the application is appropriate to the target population, the content, and the purpose; to provide the necessary technical sub-structure and the physical environment; to make it realistic and interesting; and to determine the environment and the materials to be used. These data are shown in detail in Table 2.

TABLE II. POINTS TO CONSIDER IN THE PROCESS OF DESIGN AND DEVELOPMENT

Points to consider in the process of design and development	
Points to consider	***n***
Appropriateness for the target population	32
Appropriateness for the purpose and the content	21
Providing the necessary technical sub-structure and the physical environment	14
Making it realistic and interesting	13
Determining the environment and the materials to be used	10
Designing the markers (size, color, number) in a way that they will be recognized by the software and by the camera	10
Making it easy to use, including providing the necessary guidance	7
Including a variety of multimedia elements	6
Designing the markers appropriately for the subject and for the target population	6
Conduct pilot applications	5
Good-planning during the process	5
Good-quality audios and images	3
Cooperation between the field experts	2
Lack of distracting factors	2
Providing feedback and reinforcers	2

C. Points to consider in the process of implementation

The participants reported that in the application process of the educational AR application, it is important to provide the necessary technical sub-structure and the physical environment, to inform the students (about the program,

materials, purpose, gains), and to provide them with equal opportunities for application. This data is shown in Table 3.

TABLE III. POINTS TO CONSIDER IN THE PROCESS OF IMPLEMENTATION

Points to consider in the process of implementation	
Points to consider	***n***
Providing the necessary technical sub-structure and the physical environment (light, audio, class order, etc.)	42
Informing the students (about the program, materials, purpose, gains)	18
Providing students with equal opportunities for implementation	8
Offering education within the framework of the plan	7
Conducting usability tests of the materials to be presented to the students	5
Designing the educational materials to be appropriate for the design principles	4
Helping students become active in the process	4
Achieving class management	3
Adjusting the camera well in webcam applications	3
Preventing younger students from regarding the application as a game	2
Allocating enough time to the students for the application	2

I. DICUSSION

The aim of the study is to reveal points to take into consideration while developing an effective educational AR application. In this context the process of analysis, design, development and implementation are examined in educational AR applications.

Points to be considered while developing an effective educational AR application were examined in relation to the stages of software selection, design, development, and application. Factors to be taken into consideration in the process of software selection are easy interfacing of the program, multimedia support for the program, the creation of an environment in which the application will be conducted, and related devices that will be needed. Although Clark suggested that pedagogy should a primary consideration rather than technology [10]. Kozma argued that designers should use the most advantageous technologies to develop effective educational applications [11].

Because AR technology is a newly-developing technology, it is inevitable that there will be certain limitations caused by current software. Therefore, th software selection is important. Studies have been conducted to compare recently developed software programs [12], [13]. Regarding the processes of design and development, other important points that should be taken into consideration include appropriateness for the target population, for the subject content, and for the purpose; providing the necessary technical sub-structure and physical environment; and making the environment realistic and interesting. All of these points should be taken into consideration as designers attempt to construct an effective teaching environment. In addition, it is also important not only to determine the environment and the materials to be used with the AR technology, but also to design the markers (size, color, and number) in a way that they will be recognized by the software and the camera. As is stated in the literature, if the learning environment is not well-designed, students will feel discomfort. This could detrimentally impact learning, such as by causing low engagement [7]. Providing the necessary technical sub-structure and physical environment are among the factors that should be taken into consideration in the application process. Effective applications of AR technology seem to require special physical conditions, equipment, and software. In addition, it is also important in an application to inform the students (about the software, materials, purpose, and gains) and to provide them with equal application opportunities.

II. CONCLUSION

To conclude, easy interfacing of the program, multimedia support of the program, the environment where the application will be implemented, and the related devices to be used should be primarily taken into consideration. In the process of design and development process, it is important to determine whether the application is appropriate to the target population, the content, and the purpose. In the implementation process, it is important to provide the necessary technical sub-structure and the physical environment, to inform the students (about the program, materials, purpose, gains), and to provide them with equal opportunities for application. The results obtained in this study can be used to guide future educational implementations and research studies on AR technology.

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