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A Thematic Review of Teacher Candidates Impressions on Augmented Reality Enhanced Learning Materials

Yasin Ozarslan

Department of New Media, Yasar University, Izmir, Turkey

yasin.ozarslan@yasar.edu.tr

ABSTRACT

The purpose of this study is to investigate teacher candidates' perspectives about using augmented reality enhanced learning materials. For this study, functionally enhanced OptikAR (Basic Experiments in Geometrical Optics) and visually enhanced InsectAR (Basic Insect Diversity and Classification) learning materials were used to investigate users' feelings, opinions, expectations, acceptance, pleasure and deeper emotions regarding their experience. These materials were used individually by teacher candidates according to the instructions given. Following the completion of the guides, a semi-structured interview was conducted with each participant to obtain their impressions. To this end, participants, who could analyze the application from different point of views, were preferred. Using purposeful sampling four teacher candidates from Computer Education and Instructional Technology, Educational Sciences, and Guidance and Psychological Counselling departments were selected. The findings represent four teacher candidates' perspectives from a sufficiently diverse range of education faculty. Thematic content analysis is used as a method of analyzing qualitative data generated by interviews. Data regarding the themes were interpreted through tables and direct excerpts from the related data. As a result according to teacher candidates, use of functionally enhanced (OptikAR) and visually enhanced (InsectAR) learning materials have positive effect on learning. Participants found applications interesting, funny, motivating, easy to use, and realistic. Regarding to their experience, these types of applications make learning easier, provide a flexible learning process and economically materialize abstract concepts and topics. Similarly, it was observed to have a positive effect on the satisfaction of teacher candidates. Such products will increase the will to learn and provide memorable learning. Despite the development of educationally appropriate designs, users have demanded customization options regarding the user interface. Such customization options are an important factor in learner satisfaction.

Keywords: *Augmented Reality, Augmented Reality in Education, Enhancing Learning with Augmented Reality.*

1. INTRODUCTION

Augmented Reality (AR) technology is a multidisciplinary field of computer science, involving areas like 3D Computer Graphics, Computer Vision and Human-Computer Interaction, which deals with the combination of real-world and computer-generated data (virtual reality), where computer graphics objects are blended into real video footage in real time [5]. It is not a new issue and used in fields such as: military; medicine; engineering design; robotics; telerobotics; manufacturing, maintenance and repair applications; consumer design; psychological treatments, etc. [1].

In general this is based on a few core technologies where tracking, registration and displays are the most prominent [8]. The virtual information in relation to the user's viewpoint is registered to real objects as a result of tracking. Different types of display technologies help to present this mixed information to the user. Finally, it brings virtual information or objects to any indirect view of the user's real-world environment to enhance the user's perception and interaction with the real world.

The main objective of augmented reality technology is to superimpose computer-generated information directly into a user's sensory perception [6]. According to Milgram and Kishino [12], it can be defined as any case in which an otherwise real environment is "augmented" by means of virtual or computer generated objects. Without replacing the real world you're experiencing, this technology augments virtual information on top of the real world with continuous and implicit user control of the point of view and interactivity. It provides a composite view for the user with a combination of the real scene viewed by the user and computer generated virtual scenes.

2. AUGMENTED REALITY IN EDUCATION

This new approach enhances the effectiveness and attractiveness of teaching and learning. The ability to overlay computer generated virtual things onto the real world changes the way we interact and trainings becomes

real that can be seen in real time rather than a static experience. Augmented Reality brings virtual information or objects to any indirect view of a user's real-world environment to enhance the user's perception and interaction with the real world. Augmented Reality tries to augment virtual objects on the real ones or scenes for maximizing a natural and intuitive user experience in real time. Augmented Reality can enable increased elaboration while the learner participates in an AR-based learning environment [4] [10] [13] [15]. It is an interactive environment where a real life is enhanced by virtual things in real time. Augmented Reality allows the user to see the real world and aim to supplement reality without completely immersing the user inside a synthetic environment.

Although augmented reality is in its early stages, it has a great potential in education. Augmented reality interfaces offer seamless interaction between the real and virtual worlds. Learners interact with the 3D information, objects and events in a natural way by using augmented reality systems. The educational experience offered by Augmented Reality is different for a number of reasons as Mark Billinghurst [3] mentioned:

- Support of seamless interaction between real and virtual environments
- The use of a tangible interface metaphor for object manipulation
- The ability to transition smoothly between reality and virtuality

Applications of Augmented Reality may be used in many ways to provide significant value in education and for learning. Learners can change the position, shape, and/or other graphical features of virtual objects with interaction techniques augmented reality supports. Displaying information by using virtual things that the learners cannot directly detect with their own senses. Enable learners to interact with the real world in ways never before possible. Using theirs fingers or motions of handheld devices such as shake and tilt they have an ability to manipulate virtual objects, as well as to physical objects in the real world.

3. THE STUDY

The aim of this study was to determine how a teacher candidate feels about using a learning material which was enhanced with augmented reality. For this study, functionally enhanced OptikAR (Basic Experiments in Geometrical Optics) and visually enhanced InsectAR (Basic Insect Diversity and Classification) learning materials were used to investigate users' feelings, opinions, expectations, acceptance, pleasure and deeper emotions regarding their experience.

The participants of this study were four students (1 male and 3 female) from Computer Education and Instructional Technology, Educational Sciences, and Guidance and Psychological Counselling departments. The findings represent student perspectives from a sufficiently diverse range of education faculty. They voluntarily conducted all OptikAR and InsectAR applications by using guidelines and then participated in semi-structured interviews. Their feelings and opinions regarding OptikAR and InsectAR learning materials, were gathered.

2.1 Learning Materials Enhanced With Augmented Reality

2.1.1 OptikAR: Augmented Reality for Basic Experiments in Geometrical Optics

OptikAR is an augmented reality enhanced learning material to enhance the user experience regarding Basic Geometrical Optics and Experiments such as The Law of Reflection, Reflection and Ray Diagrams for Plane and Curved Mirrors, the Law of Refraction: Snell's Law, Total Internal Reflection, and Critical Angle. It is designed to turn hard-copies of basic experiments in geometrical optics into a digital, interactive experience.

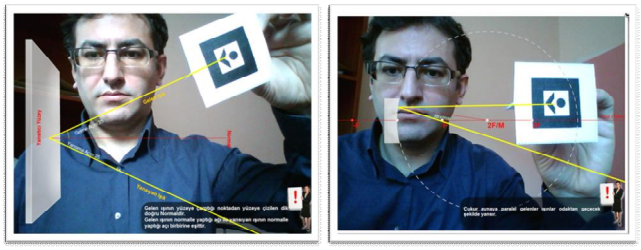

Fig. 1. Screenshots from OptikAR: Reflection and Ray Diagrams for Plane and Curved Mirrors

OptikAR is an example of a simple marker-based functionally enhanced augmented reality system. This system captures an image of the environment, detects the marker and deduces the location and orientation of the camera, and then augments a virtual light ray on top of the image and displays it on the screen. In any experiment you need to keep pointing markers to the web camera to see interactions. Depending on experiment and movements of light source marker the interaction launches.

2.1.2 InsectAR: Basic Insect Diversity and Classification

InsectAR is a series of learning tools developed to introduce basic insect diversity and classification. As mentioned earlier it is based on Augmented Reality technology and is an example of a marker-based visually enhanced augmented reality application. This system captures an image of the environment, detects the insect marker and deduces the location and orientation of the

camera, and then augments an insect on top of the image and displays 3D real insect on the screen.

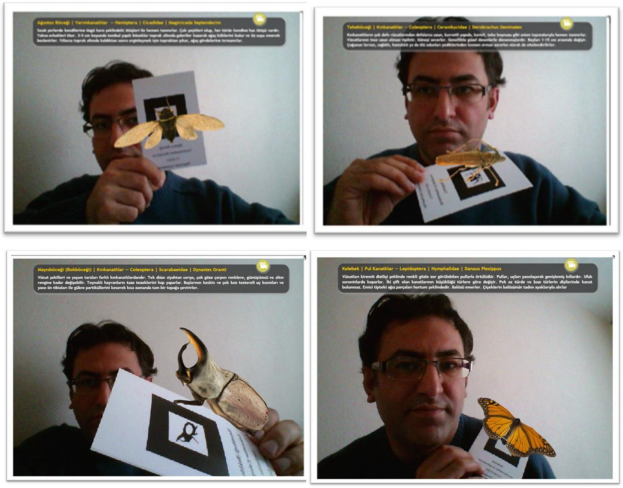

Fig. 2. Screenshots from InsectAR: Basic Insect Diversity and Classification

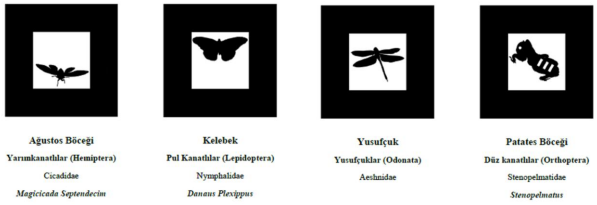

Fig. 3. InsectAR Marker Card Samples

The main objective of InsectAR is to virtually connect and engage learners with real-life insect specimens (i.e. specimens preserved in a research collection; mainly of the Southwest United States) from the Insect Collection located at Arizona State University. This technology is gaining momentum in education due to its ability to immerse learners in interactive and engaging ways.

2. 2 Participants

Following the development period, OptikAR and InsectAR was shared with users and their impressions were sought. To this end, participants, who could analyze the application from different point of views, were preferred. Using purposeful sampling four teacher candidates from Instructional Design, Psychological Guidance and Counselling, Educational Technology, Science Teaching departments were included in this study. Demographic information regarding the participants is provided in Table 1 as follows:

Table 1: Participants' demographics

Teacher Candidates	Gender	Department	Age
TC-1	Female	Instructional Designer	22
TC-2	Female	Psychological Counsellor	23
TC-3	Female	Science Education Teacher	22
TC-4	Male	Educational Technologist	23

TC-1 is a senior student at Computer Education and Instructional Technology department. She has 2 year professional experience on graphic design. She has drawing ability. She can develop 2D and 3D animations. She is successful at Instructional Design, Educational Material Development, Educational Graphics and Animations and Educational Software Development courses.

TC-2 is a senior student at Psychological Guidance and Counselling department. She is also minor student at Computer Education and Instructional Technology department. She plans to work as psychological counsellor. Moreover she is experienced in scientific research and observation. She is successful at the courses of Phycology, Philosophy, Principles of Psychological Guidance and Development Psychology. She is also successful at Instructional Design, Educational Graphics and Animations, and Educational Software Development courses in her minor department.

TC-3 is a senior student at Science Teaching department. She plans to work as science teacher. She was successful at General Physics and Physics Lab., Science Education, Instructional Design, Educational Material Development, Computer I and II courses.

TC-4 is another senior student at Computer Education and Instructional Technology department. He has 3 year professional experience on software development. He was successful at Instructional Design, Educational Material Development, Educational Graphics and Animations and Educational Software Development courses.

2.3 Method

For the research, functionally enhanced OptikAR (Basic Experiments in Geometrical Optics) and visually enhanced InsectAR (Basic Insect Diversity and Classification) learning materials were developed. These materials were used individually by teacher candidates according to the instructions given. They took part in this study utilizing their personal computers. The study conducted in the office of researcher. This process took approximately 2 hours. During this process, the researcher conducted observations and took notes. Following the completion of the instructions, a semi-structured interview was conducted with each participant to obtain their impressions. The

format of the interview is open-ended and researcher is encouraged to elaborate on the issues raised in an exploratory manner. Researcher asked the same questions to all of the participants, although not necessarily in the same order or wording. This method was preferred to enable private one to one discussions to provide rich information about the thoughts, feelings and perceptions of affected individuals.

Interviews were audio-taped with the permissions of participants and transcribed to provide the data. The interview format was read in detail. Participants' responses were grouped. A single coder completed the full coding task. After given meaningful names, code key was created. For determining consensus opinion or dissidence, another researcher read the interview data and marked on coding key. A consensus was provided among researchers to ensure the reliability of the study. The percent agreement calculated in this study is 86.23% and within the expected range as stated by Miles and Huberman [11]. Where disagreements occurred, coders discussed their options until they reached agreement.

Thematic content analysis is used as a method of analyzing qualitative data generated by interviews. Thematic analysis goes beyond simply counting phrases or words in a text and moves on to identifying implicit and explicit ideas within the data [7]. This approach involves discovering themes in the interview transcripts and attempting to verify, confirm and qualify them by searching through the data and repeating the process to identify further themes and categories [14]. In thematic analysis, the themes/categories are not set and predetermined. Researcher reviews the data to emerge them. So that as many new themes as the researcher identifies can be included. In order to do this, the interviews have been transcribed verbatim. Interview texts were read several times and headings were written down to describe different aspects of the content. In this "open coding" stage themes and categories were identified. Some of the categories and themes were so similar that researchers made judgments of the reductions. Thereafter, the shortened list of category codes were separated in different sections. The Atlas.ti software was used for the analysis of the findings. Data analyses validated by another qualitative researcher independently. Data regarding the themes were interpreted through tables and direct excerpts from the related data.

4. FINDINGS

Of the impressions gathered from the teacher candidates, 41.87% were regarding the application, 24.63% were regarding learning, 15.27% regarding their satisfaction, 13.30% were regarding other matters, and 4.93% were regarding negative impressions.

Table 2: Impressions of Teacher Candidates' regarding Augmented Reality Enhanced Learning Materials "OptikAR" and "InsectAR"

Impressions of Teacher Candidates	**TC-1**	**TC-2**	**TC-3**	**TC-4**	**TOTAL**	
	n	***n***	***n***	***N***	***n***	***%***
Impressions Regarding The Application	***11***	***23***	***32***	***19***	***85***	***41,87***
• *Interesting*	3	4	8	5	20	9,85
• *Fun*	1	5	10	4	20	9,85
• *Motivating*	1	9	5	1	16	7,88
• *Realistic*	3	2	4	6	15	7,39
• *Easy to use*	3	3	5	3	14	6,90
Impressions Regarding Learning	***11***	***17***	***10***	***12***	***50***	***24,63***
• *Eases learning*	2	4	5	4	15	7,39
• *Allows flexible learning*	3	5	1	2	11	5,42
• *Provides memorable learning*	4	1	1	3	9	4,43
• *Increases the will to learn*	0	5	1	2	8	3,94
• *Materializes the topic*	2	2	2	1	7	3,45
Impressions Regarding Satisfaction	***10***	***12***	***6***	***3***	***31***	***15,27***
Other Impressions	***3***	***8***	***12***	***4***	***27***	***13,30***
• *Wishes to use beyond learning*	1	3	5	1	10	4,93
• *Wishes to use in other courses*	1	2	5	1	9	4,43
• *Economical*	1	3	2	2	8	3,94
Negative Impressions	***4***	***1***	***3***	***2***	***10***	***4,93***
					203	***100***

n: Number of Impressions

Participants have expressed their opinions regarding the application as interesting (9.85%), fun (9.85%), motivating (7.88%), realistic (7.39%) and easy to use (6.90%).

TC-3 expressed that indicated that it was the technology itself that they found interesting;

"... holding that paper, surprised me because I felt different since seeing the reflection of light on the screen, I saw something technological. It's strange! I feel like I am in a science fiction. It is very different environment; creating a light by using a piece of paper, getting different angles of light by holding a paper to screen… It is nice in that respect"

Similarly, TC-4 expressed that this experience was different and indicates the point that drew their attention;

"… it's a different experience. Because I feel like I'm doing something. I mean, I can feel that I am sending that ray of light with that paper with my own hand..."

TC-2 expressed their enjoyment from using the application as

"… I think the best one is insects eeee .... I see directly, I feel that I see the real insects, I was very impressed to hear their voices. …it was like a collaborative learning environment we did things together."

while TC-3 indicated that in addition to the entertainment that the application method introduces, it could also supplement learning as follows;

"… such methods and visuals may be used to materialize abstract concepts and it would be fun. For example, uhh… science is a very boring class in fact and I don't like it and actually I learned it unwillingly but instead of this memorization system if you could establish it like a game for children the child may think they are playing and learn this"

however they continue to express their concerns as follows;

"Like if it were only for learning purposes they may learn while having fun. If it were like you wanted me to do this task and I had to get a grade at the end I wouldn't want to do it due to that anxiety, right now since I have no anxiety and I'm doing this just for the fun of it I tried to make the best of it…"

Regarding the motivating qualities of the application, TC-2 states;

"This technology surrounded me. In the book everything is based solely on my power of focus but here it pulled me in"

Regarding the use of the application TC-2 stated that

"I don't need any extra information to do this application I can directly adapt."

indicating no need for technical knowledge and it's ease. Meanwhile TC-3 stated

"Perhaps if I weren't using a computer in my daily life, I might need technical assistance…"

yet continued to state that everyone could easily use it;

Actually… the objects I hold are not really directly related to computer use… it's more about manual dexterity… I mean it seems like everyone can do this.

Regarding how realistic the application was TC-3 took into account their previous experiments in a laboratory environment;

"The task I was doing was the same there was no difference there regarding learning I could learn the same thing in a lab by holding real light like a flashlight. Regarding learning gains I don't think there is a difference."

Similarly, TC-1 expressed her InsectAR experience as follows;

I must say it [laughs ....] many people cannot touch these insects. So it is very advantageous to examine these things in this way. You know lots of girls, in fact most of the girls cannot look real insects easily but … using this app they can able to control easily and feel comfortable at all... I did not feel the touch sense but I felt as realistic as these insects were on my hand."

The opinions of teacher candidates regarding learning were; it makes learning easier (7.39%), it allows for flexible learning (5.42%), it provides memorable learning (4.43%), it increases the will to learn (3.94%), and it materializes the topic (3.45%).

Regarding making learning easier and regarding the flexibility that it provides, TC-1 stated the following;

"... it's even better than someone doing it in front of me in person and someone is doing it right there but I might not be able to say can you do this part again but I can repeat it with my own hand."

Similarly, TC-3 expresses her feelings about InsectAR as follows:

"… but the three-dimensional version of insect as I mentioned earlier more funny. I can easily understand these things when I saw them in 3D."

TC-2 described the provided flexibility as

"... I learn at my own learning speed. I can skip the parts I want to skip. …for example, I listened to the sound of insects at the same time looking and reading.… I can learn more convenient because it is design according to my learning style, eee.. I can manage the way I learn. I think, it would be much more useful in this respect.

while TC-1 states that in addition to the flexibility allowing them to do things themselves the experience of real experiments are more memorable;

"There is some serious flexibility here since I do it myself, and this year in optics actually we conducted experiments here at this faculty, but it can't be said that much of it can be remembered. Right now it's better, it can even compete with a real experiment. It is memorable… the most important part is like for example uhh… for example if I had seen a diagram somewhere else or even if I had watched a video maybe it wouldn't have stayed in my mind so seriously but here I can turn it right and left, right now quite most of it is in my mind..."

TC-2 expresses how despite the fact that the topic is conceptual and abstract, the application materializes it as follows;

"One of the applications I used was the physics course like actually they were abstract things when I think about it the way they were explained to us was always abstract I got the chance to directly apply them."

15.27% of the teacher candidates' expressions were about their satisfaction through their different and varying experiences. We may gather their expressions that generally they liked the system under this heading. They found the application plain, impressive and creative, and shared their pleasure regarding the fact that the application is accessible through the internet without any setup.

The will to utilize similar applications in other lessons and beyond the scope of learning along with the economical possibilities that such applications may present, were

evaluated under the 13.30% of other impressions. Regarding the use of similar applications, the science teacher TC-3 stated

"Especially it can be used in education … For example when I'll be a science teacher as a field regarding something about botany or nature, I can show the subject without taking children to the museum or zoo in daily courses"

which is similar to the statements of TC-2 indicating that transferring this system to learning would be very effective;

"… I would want to see it in other classes as well but I can't imagine how it would be applied I can't imagine I would especially want something like this in theoretical courses."

The participants expressed that they could not currently imagine how this could be implemented. However TC-2 addressed the financial advantages that such applications may provide to education as follows;

"It is not easy to access dried insects in daily life. But I want to learn or access information about them.….for physics, for chemistry with courses in such laboratory environments that are financially expensive or since our schools are so crowded the way that everyone can individually apply the methods would be appropriate."

TC-4 indicated in their related impressions that merely a computer may be sufficient for this:

For example things we can't do in real life for example this experiment with convex mirrors requires lots of tools and equipment but with this with just one software thing [showing the indicator cards in their hand] the camera computer, internet is enough.

In addition to these positive impressions of OptikAR and InsectAR from teacher candidates, 4.93% expressed negative opinions. These negative opinions consist of the visual, symbolic and textual selections in the user interface design, along with criticisms of the utility of the program and issues regarding the environment in which the study was conducted. In this regard, the following observation of TC-3 regarding the use of the left hand despite not being left handed is an important point that requires more attention in the design process

"…but for example a left handed person conducting the optical experiments by approaching from the right might be difficult. Like if I were to use my left hand rather than my right then holding from this side [indicating the marker in their hand] might be difficult for me."

The teaching candidate TC-4 expressed an issue faced regarding the unique circumstances regarding the illumination in the environment this study was conducted;

"…other than that there was an illumination problem [referring to the room lighting] and I didn't find any other issues. Oh and in some things, probably because of the light, there is a loss of sensitivity in the thing errr.. [pointing to the light ray marker] and I think that is caused by the lighting."

Generally speaking the impressions of teacher candidates regarding OptikAR and InsectAR may be gathered under these five headings. In addition to the opinions expressed above, various suggestions were made regarding the font, color and explanations provided in the user interface of the application. Enhancements were made based on these suggestions.

5. CONCLUSIONS

Augmented Reality has the potential to renew our outlook on education by utilizing more of our senses to enhance our knowledge and skills. The lack of trained experts for evaluating educational applications enriched with Augmented Reality places great importance on the opinions and impressions of the end users, in this case, learners. From an educational perspective these inputs support the development of applications utilizing Augmented Reality technology.

Teacher candidates found applications, which were enhanced with Augmented Reality, interesting, fun, motivating, easy to use, and realistic. However, further research is required for deeper evaluation. As a result, use of augmented reality enhanced learning materials were found to have a positive effect on learning in terms of making it easier, providing a flexible learning process, satisfaction, materializing abstract concepts and cost effectiveness. On the other hand, participants demanded customization options for the user interface. Such customization options are an important factor in learner satisfaction. Such products could increase the will to learn and provide memorable learning.

Today we are capable of associating the real world with virtual objects and online multimedia content through a camera and computer. At this point it is important that the real and the virtual are compatible in both position and context to achieve an understandable appearance. As far as the users are concerned, the simplicity and utility of the applications are important. These types of applications would contribute to their learning process as well as improving their academic achievement. Compatibility of the educational aspects of the applications with daily life scenarios are also paramount to increasing the appeal of the applications.

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AUTHOR PROFILES:

Yasin OZARSLAN has extensive experience in educational technology management in higher education. He received a B.S. degree in Electrical and Electronics Engineering Department and an M.S. degree in Organizational Management Program. He has a PhD in Distance Education Program of Social Sciences Institute of Anadolu University. He is an Assistant Professor in the Department of Science Culture at Yasar University, Izmir Turkey. He is also director of Yasar University Open and Distance Learning Centre. His research interest is educational technology and open and distance learning. He also gives lessons about computer programming, information and communication technologies in education, technology and entrepreneurship, technology and society, and learning management systems as an instructor.