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Triggering the Students' Positive Attitude for the Studies of Engineering Graphics Courses through the Augmented Reality Content

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***Abstract*—Contemporary researches show that triggering interest can enhance students' thinking skills, creativity, joy of learning and improved performance. The digital technologies can be beneficial for students' learning engagement and motivation. The digital context helps students to keep positivity in education process that allows to activate attention, memory, and makes learning skills better. Augmented Reality is one of technologies that lets you interact with the real world and virtual objects at the same time. Augmented Reality application enables faster comprehension of complex spatial problems and relationships, which makes it useful during the learning process of engineering graphic courses. In this paper the application of AR technologies in RTU engineering courses is described. The results of this approach will be useful for vocational school teachers, college and university teachers in the successful integration of AR technologies in the teaching process.**

***Keywords*—Augmented Reality, Engineering Education, Trigger.**

I. Introduction

The modern era is a period when the Internet and computers occupy a central place. The current generation is actively using innovative Internet technologies and digital equipment. Today's students spent their entire lives surrounded and using computers, video games, camcorders, mobile phones and all other toys and tools of the digital age. Modern students today are "native speakers" of the digital language of computers, video games and the Internet. Children first start playing games, and only later do they start learning to read and write, or these processes occur in parallel. Now it became clear that because of this omnipresent environment and the huge amount of their interaction with it, modern students think and process information in a fundamentally different way than their predecessors. They would like to get the necessary information quickly. They love the parallel process and multitasking. They prefer graphics rather than text and the game to "serious" work.

A lot of studies provide insight into the pedagogical use of digital technologies and how to trigger today's generation interest in learning using contemporary technologies. The trigger is a factor that motivates students to study and be passionate about learning. Many researchers have noted that the trigger can improve the learning motivation of students and lead to good activities during classroom [1], [2], [3]. In the educational process, a trigger is applied to promote student interest in study and support their learning. A trigger can be represented in various ways, such as videos, slides, games, animation, puzzles, textual information, problems, etc. The purpose of the triggers is to help students adapt to the courses, meet their expectations and in this way enjoy learning.

New hardware and digital tools introduced by technological developments have significantly changed the education methods, teaching process, access, use and present information. The rapid development of information technologies, including mobile devices and innovative technologies, has stimulated researches in the field of education and educational technologies since the methods of the 21st century are technology-oriented methods [4], [5]. Specific aspects of engineering graphics teaching and key principles of the elaboration of educational computer games for developing spatial imagination are studied just occasionally [6]. An attempt to measure an engineering graphics literacy was made by means of more entertaining "technological toy" – a contemporary 3D parametric modelling CAD software [7]. The students were required to prove their spatial comprehension and the skills of the interpretation of the assembly drawing by modelling in a limited period as many individual parts as possible.

The use of unattached devices and mobile applications in the educational process is becoming more common. The application of augmented reality interests as a technology that allows interacting with digital objects in a real environment through mobile applications [8]. The interactive environment between the virtual and the real world is created by supplementing virtual objects, such

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as computer text, video, graphics, and other information, into the real world. The real environment is visualized using cameras such as computers, smartphones, and tablets [9]. In this way, augmented reality is an environment where virtual objects and the real world exist together. Augmented reality technology can have a significant impact on the teaching process because it makes it possible to combine the real world with virtual learning materials and gives students the opportunity to manage these materials [10], [11]. Using this technology, a person can interact with the virtual environment and has an opportunity to actively develop the cognitive process, enrich himself with experience and have the opportunity to learn by the method of discovery. From this point of view, augmented reality provides an expanded learning environment and supports creative learning principles [12], [13].

In this paper the results of a study on the use of AR technology in teaching courses "Descriptive Geometry and Engineering Graphics" and "Civil Engineering Computer Graphics" for the students of RTU are presented. A particular attention was paid to the study of the students' feedback concerning AR application and the attitude of students to the new methodological approach introduced.

II. Augmented Reality in Learning Environments

A didactic toolkit AR-DEHAES [14] was used as an additional learning material for the course "Descriptive Geometry and Engineering Graphics" in first-year studies. The main aim was to trigger their interest in the studies they do not enjoy in a traditional way with paper and pencil, which was used for decades before in engineering studies. This was supposed to improve their spatial abilities and to help them for a better understanding of the course content and motivate students to study more deeply as well [15]. This toolkit is based on the application of the principles Augmented Reality (AR) and requires a computer and a webcam. These two "technological toys" were supposed to act as a triggering aspect. During the operations, virtual elements are visualized on the monitor. The AR-DEHAES toolkit consists of software and a book that contains exercises that must be solved by students. Each task has a marker for visualizing virtual 3D objects. The registration of virtual elements in the real world requires accurate tracking of the position and orientation of the marker (using a marker-based method). The main element of the marker is a black square containing symbols. For the program, the camera to capture the real environment and track the marker is required. The integration of the real world with a 3D virtual model occurs when the main marker is fixed by the camera. To recognize virtual objects and to display them on the screen, a marker is used, which is placed with a specific exercise.

By turning and moving the marker or changing the distance from the marker to the webcam, you can see different perspectives of the virtual model and get additional information for the exercise performance (Fig. 1). The didactic material in its structure has five levels of complexity, each of which contains several types of exercises such as: defining of surfaces and vertexes on orthographic and axonometric views; construction of orthographic views, selection of the minimum number of views for construction of an object; sketch a missing orthographic view using two views of an object; drawing of all orthographic views. To verify the correctness of the solution and the correspondence of their sketches by hand to 3D virtual models, students can visualize the 3D model in the AR environment and view the result.

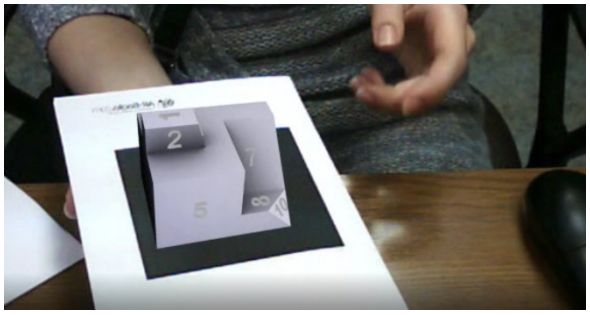

Fig. 1. Study process with application AR-DEAHAES.

During the academic semester, students became familiar with the augmented reality technology tool - the AR-DEHAES software and worked with them performing corresponding AR-BOOKS tasks. At the end of the semester, students conducted a self-assessment of spatial perception before and after using the AR-DEHAES software, using a qualitative research method – a test form. As well as spatial abilities of engineering students were measured before and after training through Mental Rotation Test. Engineering students who learned the subject with AR-training and control group mechanical engineering students having regular course performed test. Table 1 shows the scores obtained by students in the MRT test.

Table 1 Mean pre- and post-test and gain test scores (standard deviation) for experimental and control groups.

	Pre-test	Post-test	Gain
Experimental group n=48	18.12 (5.91)	23.45 (4.05)	5.33 (4.31)
Control group n=24	17.42 (5.39)	21.83 (5.08)	4.41 (4.26)

For the statistical analysis we used a Student's t-test, taking as the null hypothesis the fact that mean values for spatial visualization abilities did not vary after the end of the course. The t-test for paired series was applied and the ρ values are $\rho = 0.00000035 < 0.001$. Hence the null hypothesis is rejected, and we can conclude, with a significance level of higher than 99.9 percent, that the mean scores for the experimental group underwent a positive variation. An analysis of variance (ANOVA) was performed to determine the effect of the course type (regular or with AR training) on MRT. The analysis shows there was no significant differences between groups ($F = 0.598$, $\rho = 0.442$).

These students worked with this software for the first time, so their self-assessment objectively deserves attention. The following data was obtained from the study,

the most important of which are:

• 53% of students at the beginning of the PG and IG courses had prior knowledge of engineering graphics acquired in primary or secondary school. All students rated their spatial perception as good (50%) and mean (50%);

• 19% of students can always present the result starting to perform the graphical task. Others can do this only occasionally;

• All students recognize that working with AR-DEHAES, one can better understand the position of invisible points and edges of an object in space and allows keep interest on learning;

• 81% of respondents admit that after working with AR-DEHAES it is easier to perceive and visualize spatial objects, from which it can be concluded that augmented reality technologies help students develop spatial perception.

• 62.5% of students indicate that there are gaps in the software that should be eliminated, for example, increasing the grey contrast on surfaces and the language used should be English;

• All students, except one, recommend using this software for other students and assessed tool as entrancing and useful in the education process;

Results show that all students expressed a positive attitude to the AR material. Most students considered it interesting and they were satisfied with the additional study material technology and methodology. According to results in the Mental Rotation Test, the course "Descriptive Geometry and Engineering Graphics" enhanced with AR technology-based training material improves the spatial abilities of students (5.33 points in MRT compared with 4.41 points, obtained in a "regular" engineering graphics course).

To help students understand the training materials of the course "Descriptive Geometry and Engineering Graphics", the staff of our department prepared 3D objects from graphical tasks for placement in the AR environment. Also, according to our experience in application AR-DEHAES, the use of AR models triggers interest in the study of the graphical subject.

Augmented Reality scenes were created using the Envisage AR software. Virtual 3D models were superimposed on the environment and visualized through a computer's webcam so that they looked like part of real space. During the operation of this software, marker-based tracking is used, which means that 3D models are displayed attached to physically printed markers (Fig2, 3).

For each object, the individual marker and the 3D model were constructed, and thus the AR scene was created. To make a 3D-model was used SolidWorks. Those models were saved as STL files for subsequent import into the AR scene.

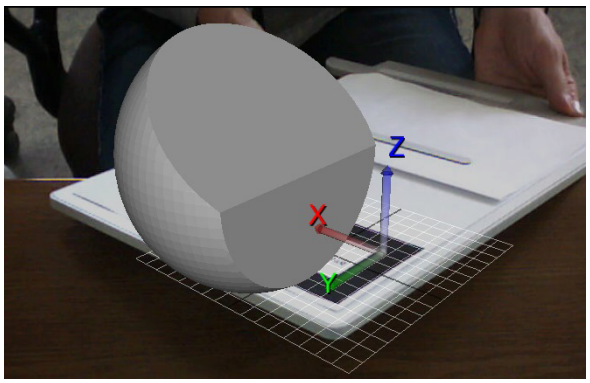

Fig. 2. AR model for exercise on Descriptive Geometry topic.

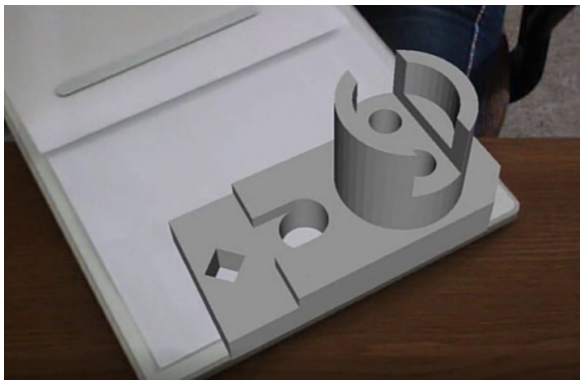

Fig. 3. AR model for exercise on Engineering Graphics topic.

To assess the effectiveness and convenience of the use of AR models in the course, at the end of the semester there were surveys in which students shared their views on AR technology. All the students found this approach very useful in solving graphic exercises. It was recognized as very interesting in general and in particular very useful for the topic of construction of multi-view projections from 3D geometric objects. In latter case it was possible to observe the transformation of the 3D AR model into 2D projections, which could be interactively manipulated in real time by observing the result on the monitor screen. The overall response of the students about the use of AR technology in the "Descriptive Geometry and Engineering Graphics" course was very positive.

Fast development of computer technology provides the possibility of the use of mobile Augmented Reality systems which are running on the smartphones. The application AR technology in the learning process of the course "Civil Engineering Computer Graphics" is based on the participation of students in the creation of AR scenes and the use of mobile devices for AR objects visualization. The students visualize their own 3D models, created by means of ArchiCAD software, using Augment – an AR SaaS platform that allows visualizing objects in the real world and in real-time through tablets or smartphones. In the quality of AR objects, the 3D digital model of a building and 3D model of the roof are used. "Roof construction" and "Building model creation" – individual exercises for students of this course.

Platform Augment has a mobile application for visualization of 3D models in AR and as well as the web interface called Augment Manager using for content

management. Augment Manager allows you to upload 3D models and trackers, edit them and share models. According to the task, students use the tracker-based method in this work. Tracker – the 2D image that should be attached to the 3D model and printed for use in the visualization process of the model. After download the Augment application to the smartphone and scan of the tracker, the corresponding 3D model of roof or building appears as part of the surrounding environment on the mobile device screen (Fig. 4).

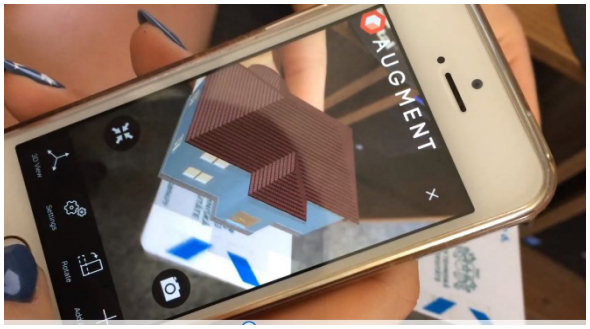

Fig. 4. Visualized AR 3D model of the building.

For visualization of 3D models, students use as tracker the top view of the corresponding object. Images should be saved in .jpg, .bmp, .png or .tga formats (Fig. 5).

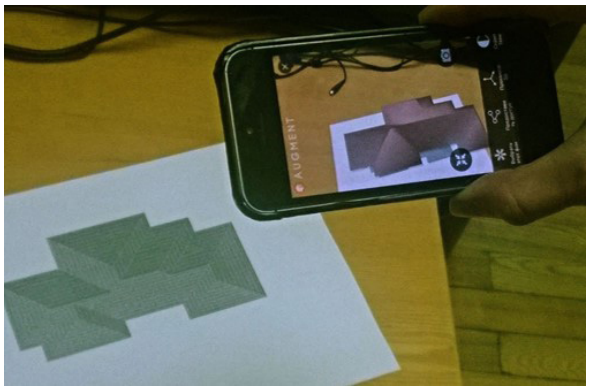

Fig. 5. Visualized AR 3D model of the roof.

According to the opinion of students, the presentation method in which performed task is shown as part of the real environment makes the learning more enjoyable. Work with AR models enhances students' imagination and creativity, helps the transfer of knowledge and skills acquired in the virtual environment to the real world. Augmented reality technologies create a realistic simulation and testing environment by transferring computerized applications to the real world and make the training and teaching process more interactive, influential, powerful and enjoyable for students, provide the students with their own unique knowledge discovery path.

III. Conclusions

In the field of education, trigger can successfully be used to stimulate student motivation to study. In the initial courses it is important to interest students, to create a positive atmosphere during the lesson. The introduction of AR technology shows positive results in the study of graphic disciplines, where students have difficulties.

The use of AR increases the effectiveness of student independent work. The amount of study hours for independent study of the course is increasing, therefore, students must learn individually, and technologies make it possible to facilitate the understanding the topic of the course significantly. In particular, it is effective in studying the geometric part of the course, where abstract thinking is necessary.

AR usage improves the quality of training, which is directly related to the quality of engineering education in general. Tests showed a positive trend in the quality of drawing performed and the spatial skills of students. A real model of an object facilitates the understanding of errors made by students in the graphical exercises.

The use of digital technologies attracts people of the today's generation, which motivates them to learn. It is important to interest students and to prevent many students from being expelled during the first year of study.

The use of AR technologies also motivates teachers to change the kind of teaching towards students and makes lessons more attractive and interesting.

This study can help university instructors, college and vocational school teachers in development of new methodological approaches with support of AR technologies.

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