E-learning: Unlocking the Gate to Education around the Globe

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APPLICATION OF AUGMENTED REALITY FOR THE TRAINING OF GEOLOGIST STUDENTS

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Abstract: The article deals with the problem of teaching foreign geology students whose native language is different from the language of learning. The basis of creating a software product capable of creating visual objects in augmented reality based on existing geological samples are considered, as well as translating their main characteristics into the native language of the student being taught. The technological preconditions for creating an application are reviewed, a review of augmented reality platforms has been carried out, an analysis of mobile devices capable of performing such an application has been carried out, and methodological foundations for creating a geological application have been outlined. In this context, in this article, we first illustrate the current needs for teaching and studying geology for students whose native language is different from the language of learning, and then we discuss the development of an multilanguage AR application for teaching geology.

Introduction

Augmented reality is an environment that in real time complements the physical world, as we see it, with digital data by using any devices - tablets, smartphones or others, and the software part. Augmented reality (augmented reality, AR) should be distinguished from virtual (virtual reality, VR) and mixed reality (MR). In augmented reality, virtual objects are projected on the real environment. Virtual reality is a world created by technical means, transmitted to a person through (for the present) the sense organs. Mixed or hybrid reality combines both apt ways. That is, virtual reality creates its own world, where a person can immerse, and augmented reality adds virtual elements to the real world. It turns out that VR interacts only with users, and AR interacts with the outside whole world (Silva, Oliveira, Giraldi 2003).

The problem of adaptation of foreign students to the learning environment in Ukrainian university represents itself as one of the actual problems which must be solved by the authorities and educators of the university. There is a problem of the adaptation of foreign students to the learning process in the Ukrainian university; it is accompanied by the development of stress and negative feelings against the background of a large study load, which, as a rule, does not meet the expectations of foreign students.

Learning vocabulary causes the greatest difficulties, the main ones being the following:

a. large amount of vocabulary language;

b. complexity of each lexical unit;

c. differences in the meaning of the words of the Ukrainian (Russian) and the students' native language (Verbitskaya 2013).

Among students at the National Technical University "Dnipro Polytechnic", quality control surveys were conducted in which there was a question about the native language. Processing of the polls showed that for students studying in English at the National Technical University "Dnipro Polytechnic" (Table 1), their native language is not English. Teaching such students often had problems concerning with insufficient vocabulary, as well as with the quality of understanding of new topics and concepts. As a result, students with English language learning showed the results of final tests 10-15 % worse than students studying in their native language (Ukrainian). At the same time, interaction with the help of materials printed in the students' native language (for example, French or Arabic), facilitated the understanding of the material.

TABLE 1. LANGUAGES PROFICIENCY LEVEL AND MARKS PROFICIENCY LEVEL OF GEOLOGY

	Native language	English	Russian	Ukrainian
Language skills	9	6,7	4,5	4,4
ILR level	5	3	2	2
level of understanding geology	n/a	5,7	3,1	3,1
level of understanding geology with handouts in English	n/a	6,2	4,3	4,3
level of understanding geology with handouts in native language	n/a	7,1	5	5,1

Source: Own.

Students attempted to translate handouts with the help of online and offline translators, however they did not always give relevant results, due to the specific terminology of geology and the mining materials under consideration.

As a result of this survey, a hypothesis about the possibility of using a specialized application for mobile devices (smartphones, tablets) capable of transmitting information about objects considered in the course with the help of augmented reality in the students' native language was put forward.

Analysis of the literature (Sirakaya and Alsancak Sirakaya 2018) showed the presence of a large number of variants for applications of augmented reality in different areas of knowledge in some works such as (Erbas and Demirer 2019; Sirakaya and Cakmak 2018; Saidin. Abd Halim and Yahaya 2015; Cabero and Barroso 2016).

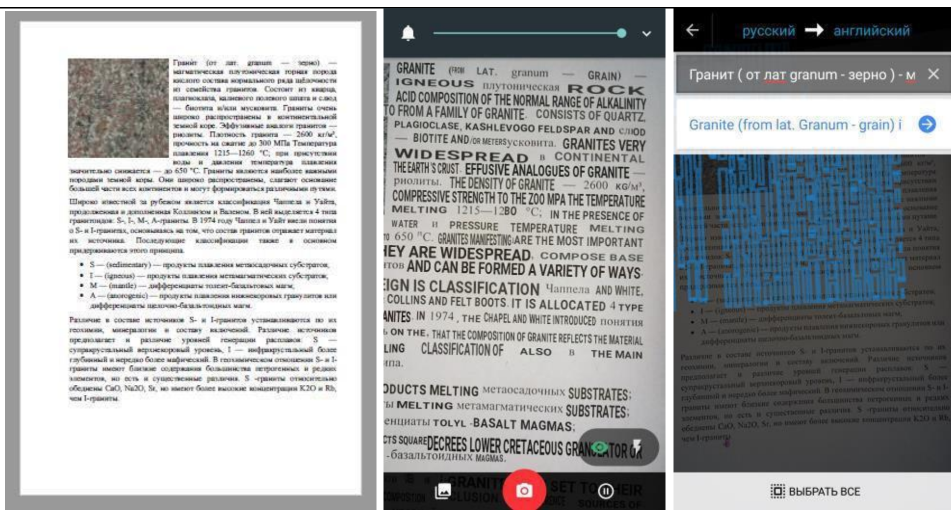
This issue consideration has led to the idea of assessing man-machine interaction and comparing the speed and quality of translation. Research in the direction of man-machine interaction was conducted by such scientists as (Rice and Lartigue 2016; Song et al. 2013), who described the qualitative and quantitative characteristics and software metrics.

Geological application

The handout used in the lectures and practical courses in geology in the 2017/18 academic year had the following parameters: a standard sheet A4 or A5 in size, which contained a black and white photo of a mineral or fossil, which flowed around the text in English or French. Arabic-language handouts were formed in the test mode; however, they were formed by students and contained a number of errors, therefore their use was limited.

Students' attempts to translate the handout text into their native language with the help of discriminating interpreters gave unstable and more often negative results due to the instability of recognizing translators to hand shake, as well as loss of quality when translating specialized geological terms.

PICTURE 1. GEOLOGICAL HANDOUT AND ITS RECOGNITION



Source: Own

For solving the problem of creating a software product, it is necessary to establish the basic requirements for it. For the application being developed, these requirements are the following:

a. Ability to be installed on wearable devices such as smartphones or tablets;

b. Interaction with the camera of wearable device;

c. Recognition of a geological object in space;

d. Application of augmented reality to the object to display its main characteristics

e. Ability to quickly change the language of the output of augmented reality; f. Ability to test students.

The second stage of development is the modelling of the application interface in order to determine the best location of controlling elements. The method of interfaces prototyping was identified as the most appropriate, and prototypes for interface elements were created with its help.

Due to the large amount of textual information accompanying the graphic elements, as well as possible accentuation of individual elements of the geological sample, it was decided to strictly horizontal orientation of the application, which allows you to display the sample in question, display explanatory comments, and change the comment language with one click as well.

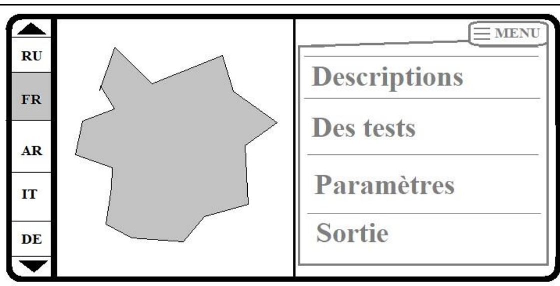
PICTURE 2. MAIN VIEW OF APPLICATION GEOAPPAR

Source: Own

An important element of the main view of application should be the menu, with the help of which it is supposed to change the modes of operation of the application (mode "augmented reality" – mode "Testing"), as well as carry out settings of the application elements.

It is supposed to make customizable font size, colour captions and size of the image coming from the camera.

PICTURE 3. APPLICATION SETTINGS



Source: Own

In the test mode, two basic types of test questions are offered for students: the choice of an appropriate sample, suitable for the description, displayed in the application, and the choice of the correct description, suitable for the displayed geological sample, as well.

PICTURE 4. TEST VIEW OF APPLICATION GEOAPPAR

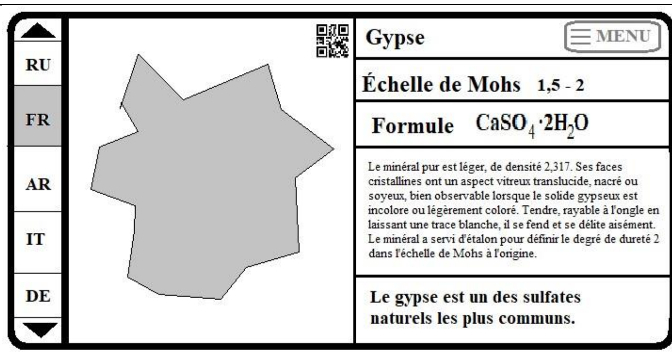
Source: Own

The second concept proposed for development mostly repeats the basic concept, but it has a key difference in the type of information recognition. The first concept in the application of augmented reality focuses on the image of a real object, available in the university collection and offered to students for identification and familiarization. The second concept of the application is focused on augmented reality indirectly and is able to generate virtual reality itself.

The key element of the second concept is the use of QR codes for generating augmented reality. Thus, the problem of the first concept is removed, which is associated with aging and contamination of the samples, which affects the quality of sample recognition and, as a result, the generation of augmented reality around it. In addition, using of QR codes in the future will allow doing without real geological samples, generating a completely virtual space based on the code only.

In the case of using QR codes, the geological sample can even be replaced with a similar one, but with a different shape, which is highly critical for the first concept. At the same time, for the second concept, the compliance of QR codes with samples is critical in order to avoid generating incorrect information, and the constant maintenance of QR codes in readable state to ensure the operation of the application, as well.

PICTURE 5. MAIN AIEW OF 2ND APPLICATION CONCEPT



Source: Own

While considering the variants of the image recognition algorithm, it was proposed to use the OpenCV library or the Point Cloud Library, however, the analysis has showed that the Point Cloud Library is more specialized for recognizing three-dimensional entities, and OpenCV specializes more in recognizing of two-dimensional images. Thus, if both libraries are suitable for the first concept, then, for the functioning of the second concept, the OpenCV library is more relevant, which makes it the optimal choice for creating both concepts.

To assess the qualitative and quantitative indicators of the system being developed, it is desirable to carry out an analysis-comparison between the system being developed and the variants of software that have been tested in training.

From the used programs, the most popular options were Google Translator for text translation and Moodle for testing.

To obtain quantitative characteristics, we will use the FLM technique described in the work (Song K., Kim J. and Cho Y.-H., Lee A. and others), where the numerical characteristics of the processes of human interaction with the interface of mobile applications were given.

For comparison, we will create a table describing the necessary interactions with the software environment to achieve the goal.

TABLE 2. COMPARISON OF THE INTERACTIONS PROGRAMS OF AUGMENTED REALITY

Operation number	Google Translate/ Quick translation mode	Actions according to FLM method	Google Translate / Translation mode through server	Actions according to FLM method	GeoAppAR application	Actions according to FLM method
1	Start of application	M+T	Start of application	M+T	Start of application	M+T
2	Launch time	R=5	Launch time	R=5	Launch time	R=5
3	Language selection	M+T+M+P+T+ M+P+T	Language selection	M+T+M+P+T +M+P+T	Autofocus	M+P
4	Camera selection	M+T	Camera selection	M+T		
5	Autofocus	M+P	Autofocus	M+P		
6			Take a photo	M+T		
7			Waiting	R=5		

Source: Own

Calculations according to the formulas used for the FLM man-machine interaction calculation methodology give the following values:

Google Translate/ Quick translation mode: M+T+R+M+T+M+P+T+M+P+T+M+T+M+P = 15,94s

Google Translate / Translation mode through server: M+T+R+M+T+M+P+T+M+P+T+M+T+M+P+ M+T+R = 22,6s

GeoAppAR application: M+T+R+M+P = 8,44s

For the second function of the developed program, functions of testing students' knowledge, we will analyse the system being developed in comparison with the system, currently used at the Dnipro Polytechnic University, the Moodle system, which has an integrated testing function.

TABLE 3. COMPARISON OF INTERACTIONS TESTING PROGRAMS

Operation number	Moodle	Actions according to FLM method	GeoAppAR Application	Actions according to FLM method
1	Browser launch	M+T+R	Start of application	M+T+R
2	Entering on the site through the link	M+T+R	Pressing MENU	M+T
3	Transition to tests	M+P+T	Pressing TESTS	M+T
4	Pressing the "Take Test" button	M+T		
Source: Own				

Calculations according to the formulas for FLM calculations give the following values:

Moodle: M + T + R + M + T + R + M + P + T + M + T = 17.07s

GeoAppAR application: M + T + R + M + T + M + T = 9.98s

Experiments in a test group of students showed the following results.

TABLE 4. COMPARISON OF TIME PROGRAM INTERACTIONS

	Google Translate/ Quick translation mode	Google Translate / Translation mode through server	GeoAppAR application AR MODE	Moodle	GeoAppAR application Testing mode
FLM data	15,94	22,6	8,44	17,07	9,98
Experimentally obtained value	16,5	23	9,0	17,5	10,5
Source: Own					

The analysis of students' progress

To select the experimental and control groups in the group of the students of the specialty "Geology", for whom the language of instruction is not native, preliminary testing was carried out in the discipline of "Geology" after studying it in the first semester of the full year of study. According to the results of testing of 30 people, two groups of 10 people were formed by pairwise selection, so that students with approximately equal scores fell into different groups. Students with the best ability to use gadgets as a second criteria fell into the experimental group. During the second semester, students of the experimental group used the developed AR-program on the classes.

After studying "Geology" in the second semester of the full year of study a final test was conducted. Test results were processed using t-test. According to the statistical results of preliminary testing, the average score of the experimental group was 69.5 points, and the average score of the control team was 69 points. Thus, we will compare the obtained t-test value (t = 0.123386, p=0.451) with the critical value for p = 0.05, which is equal to 1.734. Since the calculated value of the criterion is less than critical, we conclude that the observed differences are statistically insignificant. These calculations showed that the students of the experimental and control groups had the same level of knowledge in geology before the experiment.

Next, compare the results after training the experimental and control groups. For the analysis, test results were used before training and after training in both groups.

In the table the results of data processing after excluding the effect of covariance (test scores before the experiment) on the test results after the experiment are presented. Since the calculated value of the criterion F=170.86 is bigger than critical, we conclude that the observed differences are statistically significant ($p<0.5$)

The average score of students in the experimental group was 77.03, and the standard deviation was 8.04, the average score in the control group was 69.7, and the standard deviation was 9.73. These calculations showed that the students of the experimental and control groups had the different level of knowledge in geology after the experiment.

TABLE 5. THE ANCOVA TEST RESULTS FOR LEARNING ACHIEVEMENT FROM POST-TEST OF THE TWO GROUPS

Group	M	S.D.	Adjusted Mean	S.E.	N
Control group	69,7	9,73	69,945	0,3845	10
Experimental group	77,3	8,04	77,055	0,3845	10

Source: Own

Conclusion

This research showed that AR actions have some influence on the performance of students studying in a non-native language, using the native language of the student in the DR application. It's obvious that mastering the material in the discipline under consideration has increased when comparing student groups, which can serve as an indicator of the success of application of augmented reality applications.

In addition, the study applied a technique for evaluating man-machine interaction with mobile applications that interact with touch screens. The evaluation of this methodology, obtained as a result of experimental studies, showed a high efficiency in the use of the FLM interaction model for assessing the performance of the Person-mobile device system. The discrepancies between the model data and the experimental data can be explained by the poor preparation of some students in the handling with smartphone software.

Taking into consideration the results obtained in this study, the following recommendations are proposed to guide researchers and application developers in future AR studies:

a. During research, a conclusion was drawn confirming the statement (Sirakaya and Cakmak 2018) that using of the PD improves students' achievements. Note that similar conclusion in our case is characteristic of using the DR application for students whose native language is different from the language of instruction.

b. The primary means of communication with the PD in the carried out experiments was the students' smartphone; however, the use of tablets allows the output of more information about the object of consideration, so application of the tablets for the purposes of learning DR can be recommended.

c. Application of the FLM format is a valid approach at the level of software prototype development and can be recommended as a baseline for calculating time of the man-machine interaction.

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