Exploring Student Uses of Mobile Technologies in University Classrooms: Audience Response Systems and Development of Multimedia

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Abstract. The research is aimed at theoretical substantiation, development and experimental verification of methods of applying mobile technologies by university students. The research objective implies adapting audience response systems and mobile tools of multimedia development to be used in the classroom environment at universities. The research object is application of mobile ICT to the training process. The research subject is methods of applying audience response systems and mobile tools to conducting practical classes at the university. There are analyzed Ukrainian and foreign researches into the issues of mobile ICT application to the university students training. The authors have developed methods of applying audience response systems by taking Plickers as an example and mobile tools of multimedia development through using augmented reality tools. There is comparative assessment of functionality of audience response systems and mobile tools of developing multimedia with augmented reality. Efficiency of the developed technology is experimentally verified and confirmed.

Keywords: mobile technologies, audience response systems, development of multimedia.

1 Introduction

Application of mobile technologies was the issue for investigation in works by Mmaki

Elisabeth Jantjies [5], and Faranak Fotouhi-Ghazvini [6] (in teaching languages), Serhiy O. Semerikov [7] (in teaching Computer Sciences), Ahmad Abu-Al-Aish [8], Sakina Sofia Baharom [9], Peter W. Bird [10], Christopher Billington [11], Esra A. Wali [12], Jonathan J. Trinder [13] and Marian Hepburn [14] (in the tertiary education system), Yinjuan Shao [15] (in open education), Victoria Jotham [16] and Nee Nee Chan [17] (in everyday life).

Application of audience response systems (ARS) is described in [1], where the authors indicate that tests can be designed directly by tutors, and delivered via a network. Evaluation of the tests suggests that immediate automated testing is preferred by students compared to a traditional written test. There is evidence that the tool improves the IT skills of its users, whereas a traditional written test has no such beneficial effect.

Jenifer Santos, Luisa Parody, Manuel Ceballos, María C. Alfaro and Luis A. Trujillo-Cayado [2] described effectiveness of mobile devices as ARS in the chemistry laboratory classroom. Their paper concretizes pedagogical innovation involving smartphone technology and offers teachers the opportunity to create an environment of engaging learning in laboratories. In this paper, the authors outline how to use Socrative Student Response by Mastery Connect, a variation of a real-time ARS. They hypothesized that using this application as an ARS can enhance learning and identify student knowledge gaps in chemistry laboratory classes. In order to explore the relationships among factors and the educational effectiveness of Socrative responses, they investigated the data from a graduate-level chemistry course students. Before and after laboratory classes, experimental groups completed an ARS quiz using Socrative application in their mobile devices. The results revealed that students felt that the method enhanced their learning process whereas teachers reported that it improved academic performance and the relationships between teachers and students.

The research by Sebastian Schlucker [3] contains a report on application of mobile devices in the classroom environment and substantiates the necessity of motivating and activating elements of lectures to make as many students participate and reflect as possible. It can be done by using surveys or quizzes answered anonymously on smartphones. Quizzes are also beneficial as a university teacher can learn something about their students and their learning progress.

Dylan M. Moorleghen, Naresh Oli, Alison J. Crowe, Justine S. Liepkalns, Casey J. Self, and Jennifer H. Doherty [4] researched into the impact of automated response systems on in-class cell phone use. Their paper reveals that cell phones have long been known as a potential distraction from attention intensive activities such as studying and driving. Many, however, consider the cell phone as a powerful tool to augment some of these same activities. ARS are a type of teaching tools that allows educators to poll audience members in real time. Increasingly, cell phones are being integrated into ARS to make them more versatile and affordable. As cell phones and other personal electronic devices (tablets, laptops) are becoming more common classroom learning tools, researchers sought to explore how student cell phone use is impacted by this change. Additionally, they studied how a student's seat location and how the time during a term impacts students' cell phone use. To measure student cell phone use during lectures, introductory biology classes were observed at the University of

Washington and it was recorded when students' cell phones were visible. The authors found that students sitting in the back of the room showed an increased likelihood of having a cell phone out. However, contrary to our expectations, students using personal device (cell phone) based polling technology were no more likely to be using cell phones during lectures than their peers using traditional ARS. The results suggest that the downsides of using cell phones as teaching tools may be limited.

2 Application of mobile ICT to training

2.1 Methods of applying audience response systems

Tools of monitoring, controlling and assessing academic results are some of mobile software ICT types.

While monitoring the maturity level of students' ICT competences according to the model in [25], there are applied various monitoring tools with the testing control of knowledge being a priority. ARS are tools for assessing students' academic results.

ARS are a variety of mobile software tools aimed to measure students' academic results that enables automatizing the process of current and final control through applying modern testing tools and intensifying students' learning due to:

- ensuring mobility, cost effectiveness (efficiency) and privacy of testing through developing and implementing the technology of storing and using a short-term session of transmitting test assignments from the Internet server by wireless connection means;
- solving the problem of constraints in terms of technical characteristics and distance differentiation of teachers' and students' computers during a testing session arrangement [18].

ARS aligning with this definition include ClassMarker, EasyTestMaker, Google Forms, iSpring QuizMaker, Kahoot!, MyTestXpro, Plickers, ProProfs, etc.

In our research, we distinguish the ARS Plickers as the one providing an opportunity to arrange a rapid feedback between a teacher and an academic group including individual students; conducting a mobile survey, in-class general questioning and instant control of students' attendance. This system is beneficial in terms of high efficiency as it is very time-consuming and availability of students' smartphones or computers is not obligatory as a teacher's mobile device will do.

Plickers can be used in various operating systems of fixed computers and mobile devices. The system is meant for up to 63 students tested simultaneously. The system is noted for instant scanning of students' responses by a teacher's mobile device. The system also enables viewing students' testing results (both of a group as a whole and each student separately) in the form of a table.

To work with Plickers, a university teacher should get registered on the site (https://www.plickers.com/) and compile a library of tests on a variety of subjects (Fig. 1).

The system enables creating an academic group list while testing (Fig. 2).

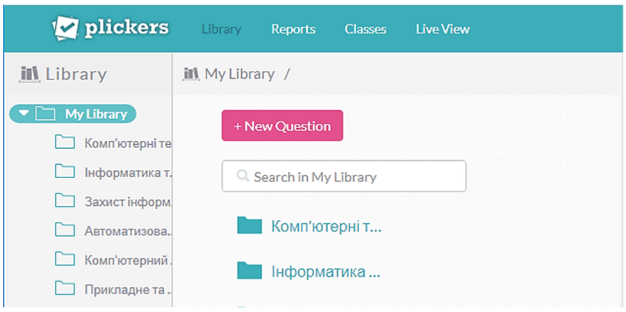

Fig. 1. The library of tests on Computer Sciences in the Plickers ARS

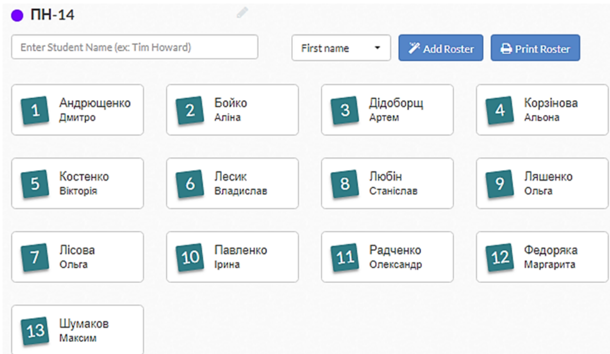

Fig. 2. The list of an academic group in the Plickers ARS

During testing, students are provided with cards with QR-codes (https://www.plickers.com/PlickersCards_2up.pdf) containing response options A, B, C, and D (Fig. 3). After reading a question, students raise a card with a chosen response scanned by a teacher's mobile device.

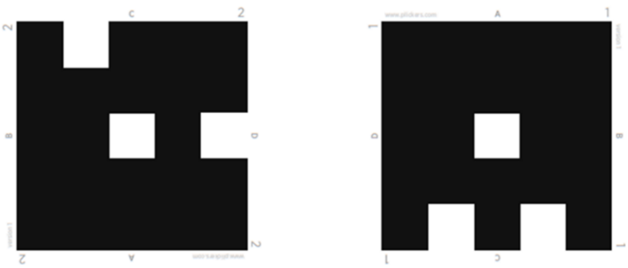
Fig. 3. Plickers cards with QR-codes

After scanning QR-codes of the cards, the data from the teacher's mobile device is transmitted to the Plickers cloud where they are processed and stored. Plickers enables either analysis of individual students' results or a general characteristic of a student group's statistics.

After scanning QR-codes of the cards, the data from the teacher's mobile device is transmitted to the Plickers cloud where they are processed and stored. Plickers enables either analysis of individual students' results or a general characteristic of a student group's statistics.

To make a survey, a teacher uses the Plickers site in the section LiveView (Fig. 4), which has a special mode of viewing questions controlled by a mobile device.

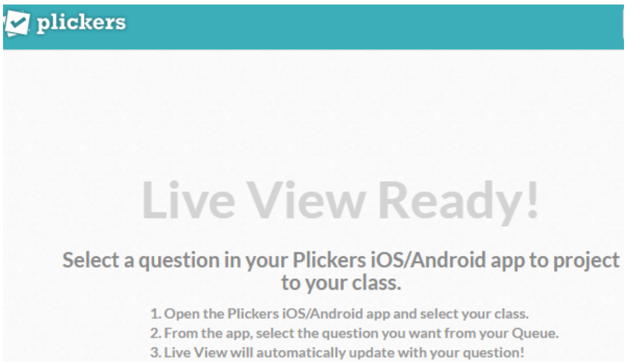

Fig. 4. The LiveView mode

To scan students' responses, you should open Plickers and choose an academic group on its main screen (Fig. 5).

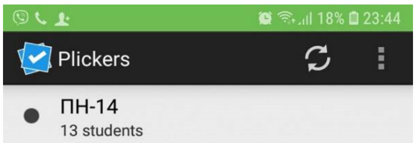

Fig. 5. The main page of the Plickers ARS

Students' use Plickers cards in Informatics class at Kryvyi Rih National University (Fig. 6).

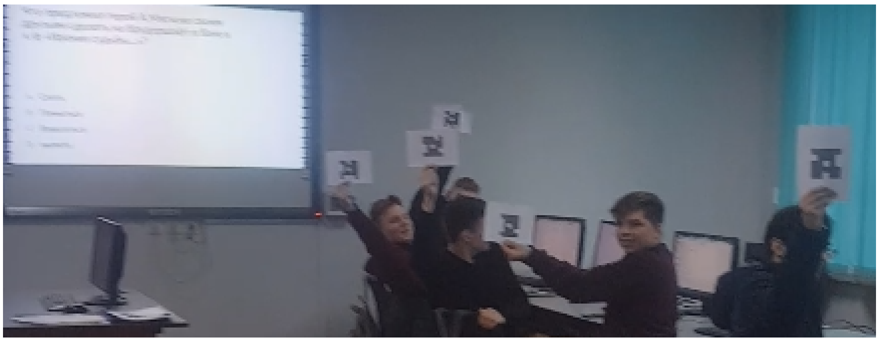

Fig. 6. Students' Plickers cards in class

Table 1 gives comparison of functionality of mobile ARS. Among various tools under analysis, attention should be paid to Plickers that enables combining of mobile device and augmented reality into a single multimedia environment.

Table 1. Assessment functionality of audience response systems

ARS / Features	Class–Marker	Easy–Test–Maker	Google Forms	iSpring Quiz–Maker	Kahoot!	MyTestX–pro	Plic–kers	Pro-Profs
Assignment types								
choosing one of two contrary	+	+	+	+	+	+	+	+
choosing one of many	+	+	+	+	+	+	+	+
multiple-choice	+	+	+	+	+	+	–	+
relevance	+	+	+	+	+	+	+	+
open response	+	+	+	+	+	+	+	+
Others								
availability of a web-version	+	–	+	–	+	–	+	–
possible independent work	+	–	–	–	–	–	+	–
Ukrainian localization	–	–	+	–	–	–	–	–
iPhone OS and Android.	–	+	–	+	–	+	+	+
availability of full-scale free version	–	–	+	–	+	+	+	+
cloud storage	+	–	+	–	+	–	+	–
minimal requirements to a mobile device	+	–	–	–	+	–	+	–
Rating	**9**	**6**	**9**	**6**	**9**	**7**	**10**	**7**

2.2 Methods of applying mobile tools of multimedia development

Combination of various ways of data presentation is the core of the multimedia learning theory developed by Richard E. Mayer who distinguishes four cognitive processes – choice, arrangement, transformation and integration of data [19, p. 118]. Selected text and graphical data are processed separately first. Next, selected data are arranged into two separate models for word and graphical data. While being processed, word data can be transformed into graphical ones (for example, by building mental images) and vice versa (by using internal verbalization of images). To successfully accomplish multimedia learning, both models should be integrated and associated with previously acquired knowledge [19].

According to Mayer [20], there are three basic approaches to presenting multimedia materials:

1. according to transmitting channels – by two or more devices (for example, a screen and speakers);
2. according to transmitting modes – text- and graphics-based (screen texts and animation);
3. according to perceptive modality – audial and visual (animation accompanied by narration).

Each of these approaches is relevant to a separate class of multimedia development tools: the first class (tools of video-data designing), the second class (presentation designing tools), and the third one (augmented reality tools including Augment, Blippar, Amazon Sumerian, Anatomy 4D, AR Flashcards Space Lite, AR Freedom Stories, AR-3D Science, Chromville, Elements 4D, HP Reveal, and Google Lens. With any approach applied, Mayer insists on the following principles of multimedia development to be guided by [20, p. 59–60]:

1. The multimedia principle: people learn by words and images better than by words only.
2. The space vicinity principle: people learn better when corresponding words and images go together and not far from each other on a page or screen.
3. The time adjacency principle: people learn better, when corresponding words and images go simultaneously and not in succession.
4. The coherence principle: people learn better, when irrelevant words, images and sounds are off and not on.
5. The modality principle: people learn better by using animation and narration than by animation and a screen text.
6. The excessiveness principle: people learn better by using animation and narration than by animation, narration and a screen text.
7. The personalization principle: people learn better, when words are presented in spoken language than in formal one.
8. The interactivity principle: people learn better, when they control the presentation pace.
9. The signalization principle: people learn better, when words contain markers on presentation arrangement.
10. The principle of individual distinctions: multimedia effects affect low-level students better than high-level ones. Multimedia effects are more powerful for highly professional students than for low-professional ones.

Observance of these principles enables us to declare that any system in compliance with them is a mobile tools of multimedia development.

Application of mobile tools of multimedia development allows increasing efficiency of controlling students’ attention span and motivation.

Considering the fact that methods of using tools of designing videos and presentations are revealed in [22; 23; 24], it is more reasonable to deal with mobile tools of augmented reality development in this paper.

To arrange students' activity while studying Computer Technologies in Education, we apply the system Blippar [21], which enables multimedia projects of augmented reality to be implemented. Fig. 7 gives a generalized model of applying Blippar to professional training.

Blipp is a Blippar object containing the scene elements and a relevant marker. To create a Blippar object, you should select Create Blipp on the My Blipps menu or create a new project, which will contain this object (Fig. 9). The Blippar object can be created visually either by combining 3D objects and animation or by using JavaScript (Fig. 10). The visual method is the simplest.

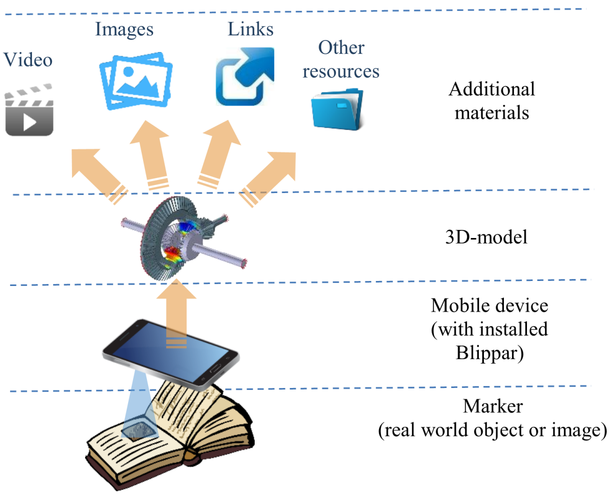

Fig. 7. The model of applying Blippar to professional training (according to [22])

Before performing a multimedia project with augmented reality in Blippar, one should get registered on their official site – https://accounts.blippar.com/signup/free (Fig. 8).

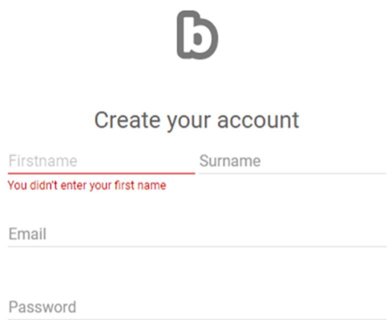

Fig. 8. Registration on the Blippar site

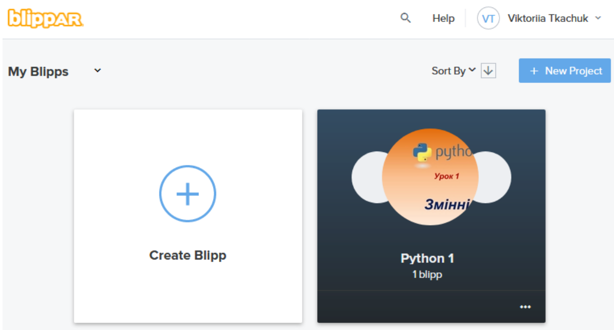

Fig. 9. Creation of the Blippar object (1)

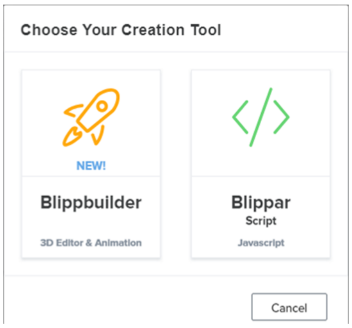

Fig. 10. Creation of the Blippar object (2)

The first step implies uploading or generating an image that will be used as a marker (Fig. 11).

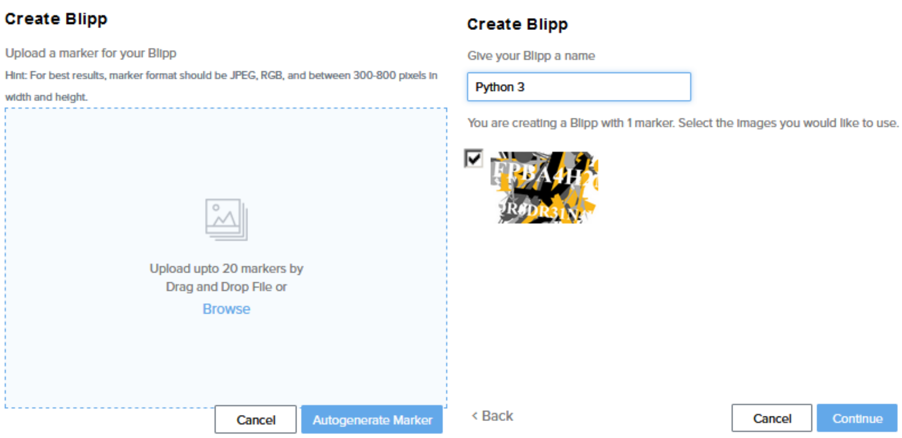

Fig. 11. Selecting a method of marker creation.

The second step involves creation of a scene by using the visual editor BlippBuilder (Fig. 12) to provide a user with panels Elements (simple geometrical 3D objects and text), “Widgets” and “Uploads” (to upload models in FBX format).

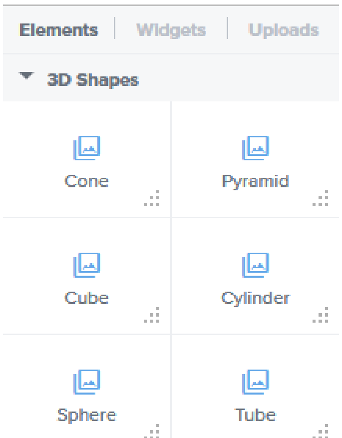

Fig. 12. Editing panels of BlippBuilder

In the editing box, one can add figures and text and activate or deactivate them in the menu, select a front, colour (select from the options or set colour by a number, for example #778899), transparency, size, position and rotation (Fig. 13), add external references, upload a video/audio, etc.

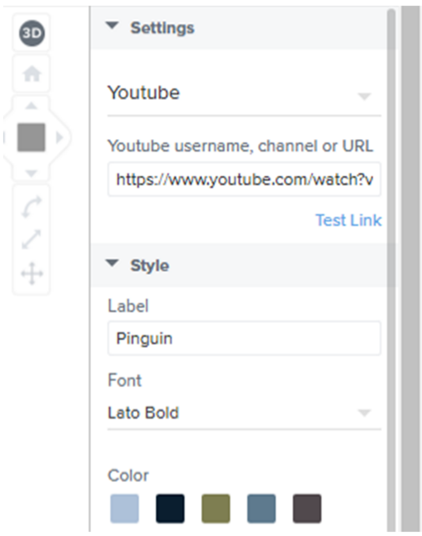

Fig. 13. Settings of Blippar scene elements

The third step involves viewing and demonstrating the Blippar object after completing scene adjustment (Fig. 14).

Fig. 14. Preview/demonstration of the Blippar object

For each Blippar object, a unique code is generated that enables its viewing in the mobile device (Fig. 15). To view the Blippar object, one should download an augmented reality browser and enter the code of the Blippar object in its settings. After that, the Blippar browser will recognize the object marker and download the relevant scene.

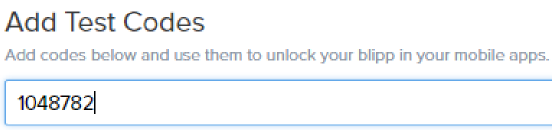

Fig. 15. The code for viewing the Blippar object

Fig. 16 shows the marker for Code 1048782 associated with the video-lesson *Changes in Python language*.

Fig. 16. The example of the marker of the Blippar object

Table 2 gives comparison of functionality of mobile tools with augmented reality. Among various tools under analysis, attention should be paid to Amazon Sumerian that enables combining tools of virtual and augmented reality into a single multimedia environment based on the web-browser supporting WebGL 2.0 and WebXR 1.0.

Table 2. Assessment of functionality of mobile tools of multimedia development with augmented reality

Mobile tools of Multimedia development with augmented reality / Features	Amazon Sumerian	AR Flashcards Space	AR-3D Science	Augment	Blippar	Chromville	Elements 4D	HP Reveal
Free dissemination	±	–	±	±	+	+	+	±
Development of one's own objects	+	+	–	+	+	–	–	+
Localization	–	–	–	–	–	–	–	–
Support of different platforms	+	–	–	+	+	+	+	+
Support of visual editing of objects	+	+	+	+	+	+	+	+
Support of various scientific fields	+	+	–	+	+	–	–	+
Rating	**4,5**	**3**	**1,5**	**4,5**	**5**	**3**	**3**	**4,5**

3 Results of experimental examination of the suggested methods

To examine the method, we determine criteria of efficiency of applying exploring student of mobile technologies in university classrooms, their indices and research methods (Table 3). Research based on experimental studies [23].

The pedagogical experiment was conducted at Kryvyi Rih National University, Kryvyi Rih State Pedagogical University, Kryvyi Rih College of National Aviation University, Kryvyi Rih Economic Institute of Kyiv National Economic University named after Vadym Hetman during of 2019-2020 educational year. Engineering Students were engaged in the experiment comprising 33 students of the experiment group and 32 students of the control group.

According to the 1st criteria, the number of students of the experiment group with high and medium motivation for training activity is larger than that of the control group by 9,94%. The 2nd criteria reveal the number of students of the experiment group with high and medium level of systematic accomplishment professional-oriented tasks which is larger than that of the control group by 12,97%. The 3rd criteria reveal the number of students of the experiment group with high and medium level of formation professional competencies which is larger than that of the control group by 13,07% (Table 4). After generalizing the results of the pedagogical experiment, we can conclude that the developed methods of applying exploring student of mobile technologies in university classroom are quite efficient, especially in terms of raising students' professional competencies. The total experiment results are given in Fig. 17.

Table 3. Criteria of efficiency of applying mobile technologies in university classrooms

Criterion of efficiency of applying mobile technologies		Index of efficiency of applying of mobile technologies in university classrooms	Levels of formation	Research methods
1st	Students' motivation for training activity	Availability of students' desire to study, perform complicated tasks; understanding of significance of studies	High; medium; low	Questionnaire "Motivation students' to use of mobile technologies in university classroom"
2nd	Systematic accomplishment professional-oriented tasks	Timely accomplishment of tasks	High; medium; low	Results of accomplishment tasks in setting time
3rd	Formation professional competencies	Availability of students' theoretical knowledge; a skill to independently accomplish tasks; objective assessment of students' own results; formed professional competencies	High; medium; low	Module test

Table 4. Experimental results

Criterion of efficiency of applying mobile technologies	Levels	Control group		Experiment group	
		number of people	%	number of people	%
Students' motivation for training activity	high	5	15,63	7	21,21
	medium	18	56,25	20	60,61
	low	9	28,13	6	18,18
	Total	**32**	**100**	**33**	**100**
Systematic accomplishment professional-oriented tasks	high	5	15,63	7	21,21
	medium	18	56,25	20	60,61
	low	9	28,13	6	18,18
	Total	**32**	**100**	**33**	**100**
Formation professional competencies	high	5	15,63	7	21,21
	medium	18	56,25	20	60,61
	low	9	28,13	6	18,18
	Total	**32**	**100**	**33**	**100**

4 Conclusions

While investigating potentials of mobile technologies used by university students, we obtained the following results:

1. researches on the issues of mobile technology application in the classroom environment are analyzed;

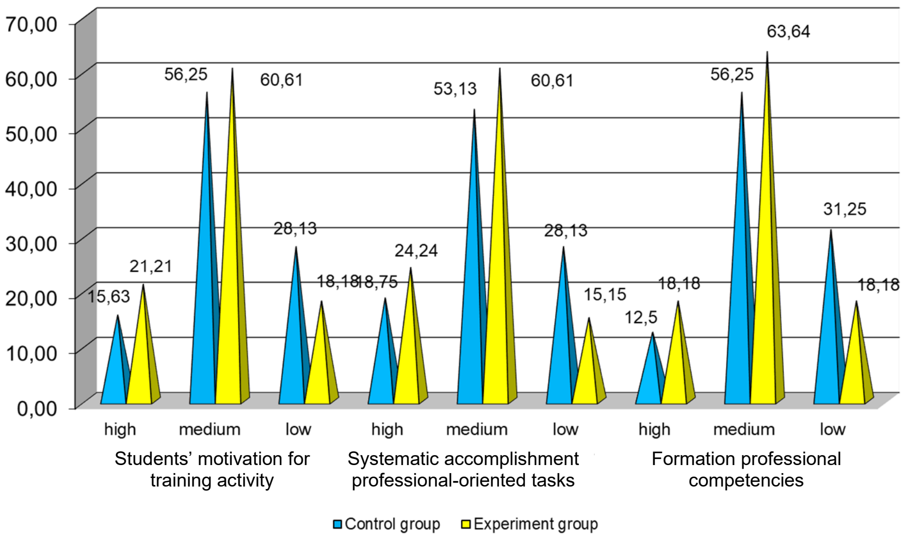

Fig. 17. Generalized results of the experiment

2. methods of applying audience response systems by taking Plickers as an example and mobile tools of multimedia development through using augmented reality tools are developed;
3. functionality of audience response systems and mobile tools of multimedia development with augmented reality are compared and assessed;
4. efficiency of developed methods is experimentally verified and confirmed, namely the results of the "Students' motivation for training activity" criterion increased by 5,58% at the high level and by 4,36% on average; the results of the "Systematic accomplishment professional-oriented tasks" criterion increased by 5,49% at the high level and by 7,48% on average; the results of the "Formation professional competencies" criterion increased by 5,68% at the high level and by 7,39% on average.

References

1. Salzer, R.: Smartphones as audience response systems for lectures and seminars. Analytical and Bioanalytical Chemistry **410**, 1609–1613 (2018). doi:10.1007/s00216-017-0794-8
2. Santos, J., Parody, L., Ceballos, M., Alfaro, M.C., Trujillo-Cayado, L.A.: Effectiveness of mobile devices as audience response systems in the chemistry laboratory classroom. Computer Applications in Engineering Education **27**(3), 572–579 (2019). doi:10.1002/cae.22098
3. Schlücker, S.: Das Smartphone – ein Antwortgerät. Nachrichten aus der Chemie **65**(2), 164–166 (2017). doi:10.1002/nadc.20174054959
4. Moorleghen, D.M., Oli, N., Crowe, A.J., Liepkalns, J.S., Self, C.J., Doherty, J.H.: Impact of automated response systems on in-class cell phone use. Biochemistry and Molecular Biology Education **47**(5), 538–546 (2019). doi:10.1002/bmb.21257

5. Jantjies, E.M.: A framework to support multilingual mobile learning: A South African perspective. Dissertation, University of Warwick (2014)
6. Fotouhi-Ghazvini, F.: Mobile Learning using Mixed Reality Games and a Conversational, Instructional and Motivational Paradigm: Design and implementation of technical language learning mobile games for the developing world with special attention to mixed reality games for the realization of a conversational, instructional and motivational paradigm. Dissertation, University of Bradford (2011)
7. Modlo, Ye.O., Semerikov, S.O., Nechypurenko, P.P., Bondarevskyi, S.L., Bondarevska, O.M., Tolmachev, S.T.: The use of mobile Internet devices in the formation of ICT component of bachelors in electromechanics competency in modeling of technical objects. In: Kiv, A.E., Soloviev, V.N. (eds.) Proceedings of the 6th Workshop on Cloud Technologies in Education (CTE 2018), Kryvyi Rih, Ukraine, December 21, 2018. CEUR Workshop Proceedings **2433**, 413–428. http://ceur-ws.org/Vol-2433/paper28.pdf (2019). Accessed 10 Sep 2019
8. Abu-Al-Aish, A.: Toward mobile learning deployment in higher education. Dissertation, Brunel University (2011)
9. Baharom, S.S.: Designing Mobile Learning Activities in the Malaysian HE Context: A Social Constructivist Approach. Dissertation, University of Salford (2013)
10. Bird, P.W.: Potentially disruptive IS innovation in UK higher education institutions: An Actor-Network Theory analysis of the embedding of M-Learning. Dissertation, Manchester Metropolitan University (2014)
11. Billington, C.: Psychosocial influences on the use and regulation of mobile phones in high schools. Perspectives from pupils, teachers and parents, an exploratory case study approach. Dissertation, University of Birmingham (2011)
12. Wali, E.A.: Reinterpreting Mobile Learning: an Activity Theoretic Analysis of the Use of Portable Devices in Higher Education. Dissertation, University of London (2008)
13. Trinder, J.J.: Mobile Learning Evaluation: The Development of Tools and Techniques for the Evaluation of Learning Exploiting Mobile Devices Through the Analysis of Automatically Collected Usage Logs – An Iterative Approach. Dissertation, University of Glasgow (2012)
14. Hepburn, M.: Investigating the potential for new media and new technologies in design and technology undergraduate education. Dissertation, Loughborough University (2012)
15. Shao, Y.: Mobile group blogging in learning: a case study of supporting cultural transition. Dissertation, University of Nottingham (2010)
16. Jotham, V.: iSpace? Identity & Space – A Visual Ethnography with Young People and Mobile Phone Technologies. Dissertation, University of Manchester (2012)
17. Chan, N.N.: Learning with Smartphones: A Hermeneutic Phenomenological Study of Young People's Everyday Mobile Practices. Dissertation, University of Durham (2013)
18. Rizun, N.O., Taranenko, Y.K.: Mobilna systema komp'iuternoho testuvannia yak instrument intensyfikatsii navchalnoho protsesu VNZ (Mobile system of computer testing as the instrument of intensification of study process in higher education institutions). Radio Electronics, Computer Science, Control 1, 129–134 (2012). doi:10.15588/1607-3274-2012-1-24
19. Mayer, R.E.: Multimedia learning: Second Edition. Cambridge University Press, New York (2009)
20. Mayer, R.E.: Multimedia Learning. http://ateneu.xtec.cat/wikiform/wikiexport/_media/cursos/tic/d206/modul_1/multimedialearningmayer.pdf (2008). Accessed 17 Dec 2019

21. Create & Make Augmented Reality Using Blippbuilder Tools – Blippar. Computer Vision Company | Blippar. https://web.blippar.com/blipp-builder#Blippbuilder (2019). Accessed 28 Oct 2019
22. Striuk, A.M., Rassovytska, M.V., Shokaliuk, S.V.: Using Blippar Augmented Reality Browser in the Practical Training of Mechanical Engineers. In: Ermolayev, V., Suárez-Figueroa, M.C., Yakovyna, V., Kharchenko, V., Kobets, V., Kravtsov, H., Peschanenko, V., Prytula, Ya., Nikitchenko, M., Spivakovsky A. (eds.) Proceedings of the 14th International Conference on ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer (ICTERI, 2018), Kyiv, Ukraine, 14-17 May 2018, vol. II: Workshops. CEUR Workshop Proceedings **2104**, 412–419. http://ceur-ws.org/Vol-2104/paper_223.pdf (2018). Accessed 30 Nov 2018
23. Yechkalo, Yu.V., Tkachuk, V.V., Hruntova, T.V., Brovko, D.V., Tron, V.V.: Augmented Reality in Training Engineering Students: Teaching Techniques. In: Ermolayev, V., Mallet, F., Yakovyna, V., Kharchenko, V., Kobets, V., Korniłowicz, A., Kravtsov, H., Nikitchenko, M., Semerikov, S., Spivakovsky, A. (eds.) Proceedings of the 15th International Conference on ICT in Education, Research and Industrial Applications. Integration, Harmonization and Knowledge Transfer (ICTERI, 2019), Kherson, Ukraine, June 12-15 2019, vol. II: Workshops. CEUR Workshop Proceedings **2393**, 952–959. http://ceur-ws.org/Vol-2393/paper_337.pdf (2019). Accessed 30 Jun 2019
24. Tkachuk, V.V., Yechkalo, Yu.V., Markova, O.M.: Augmented reality in education of students with special educational needs. In: Semerikov, S.O., Shyshkina, M.P. (eds.) Proceedings of the 5th Workshop on Cloud Technologies in Education (CTE 2017), Kryvyi Rih, Ukraine, April 28, 2017. CEUR Workshop Proceedings **2168**, 66–71. http://ceur-ws.org/Vol-2168/paper9.pdf (2018). Accessed 21 Mar 2019
25. Tkachuk, V.V., Shchokin, V.P., Tron, V.V.: The Model of Use of Mobile Information and Communication Technologies in Learning Computer Sciences to Future Professionals in Engineering Pedagogy. In: Kiv, A.E., Soloviev, V.N. (eds.) Proceedings of the 1st International Workshop on Augmented Reality in Education (AREdu 2018), Kryvyi Rih, Ukraine, October 2, 2018. CEUR Workshop Proceedings **2257**, 103–111. http://ceur-ws.org/Vol-2257/paper12.pdf (2018). Accessed 30 Nov 2018